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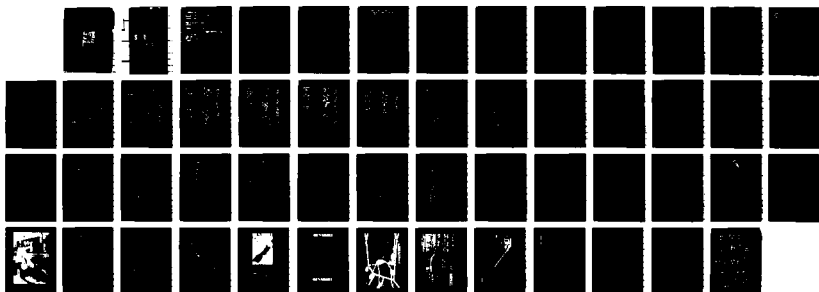
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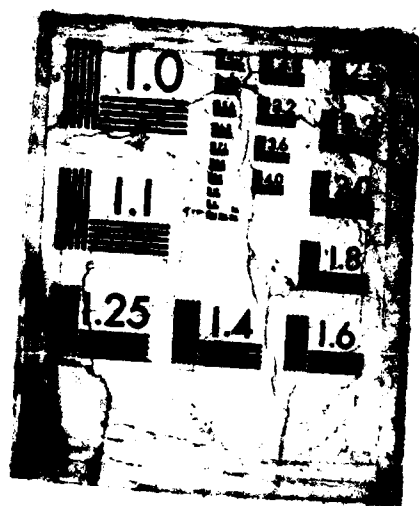
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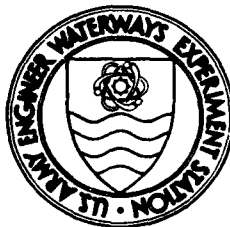
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**COMMENTS ON TWENTY-FIRST CONGRESS  
INTERNATIONAL ASSOCIATION FOR HYDRAULIC  
RESEARCH (IAHR), MELBOURNE, AUSTRALIA  
19-23 AUGUST 1985**

by  
**F. R. Brown**

**DEPARTMENT OF THE ARMY  
Waterways Experiment Station, Corps of Engineers  
PO Box 631, Vicksburg, Mississippi 39180-0631**

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<p>This report describes the author's experiences at the Twenty-First Congress, International Association for Hydraulic Research (IAHR), in Melbourne, Australia, 19-23 August 1985. The author reports on the Congress and the post-Congress tours to sites of scientific interest in Australia, New Zealand, and Tahiti.</p> <p>The purpose of his mission was to obtain state-of-the-art knowledge in the field of hydraulics on a worldwide basis for application by the US Army Corps of Engineers.</p>					
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## Preface

This report summarizes the attendance of Mr. Fred Brown, former Technical Director of the US Army Engineer Waterways Experiment Station (WES), at the Twenty-First Congress of the International Association for Hydraulic Research (IAHR), Melbourne, Australia, 19-23 August 1985, under Invitational Travel Order I85-377, Appropriation No. 2152020, Operation and Maintenance, Army.

COL Dwayne G. Lee, CE, is the Commander and Director of WES.

Dr. Robert W. Whalin is the Technical Director.



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## Contents

	<u>Page</u>
Preface.....	1
Introduction.....	3
IAHR Congress.....	3
Arrangements.....	3
Attendance.....	4
Program.....	4
Comments.....	6
Post-Congress Technical Tour.....	6
New Zealand Tour.....	7
Tahiti.....	8
Appendixes A-F	

COMMENTS ON TWENTY-FIRST CONGRESS, INTERNATIONAL  
ASSOCIATION FOR HYDRAULIC RESEARCH (IAHR),  
MELBOURNE, AUSTRALIA, 19-23 AUGUST 1985

Introduction

1. In accordance with Invitational Travel Order 185-377 (Appendix A), I attended the Twenty-first Congress of the International Association for Hydraulic Research (IAHR) held in Melbourne, Australia, on 19-23 August 1985. I departed Los Angeles, California, on 16 August and traveled to Melbourne by way of Tahiti and Auckland, New Zealand, arriving on 18 August about 1250. I attended the entire meeting, 19-23 August, and participated in the Post-Congress Study Tour 1, which left Melbourne on 24 August. Travel included Alice Springs, Ayers Rock, and Sydney. I left Sydney, Australia, on 28 August for my return to the United States, touring New Zealand during the period 29 August-6 September and Tahiti during 6 September-13 September. I arrived in Los Angeles at 1735 on 13 September. All travel and stops other than for attendance at the Congress were at my personal expense. I was accompanied by my wife. Travel arrangements were made by American International Travel, Inc., of Vicksburg, Mississippi.

2. Simultaneously with the Congress, the International Measurement Confederation (MEKO) held an International Conference on Flow Measurement (FLOMEKO). Registration permitted IAHR participants to attend sessions.

IAHR Congress

Arrangements

3. The hosts for the Twenty-first Congress were the Institution of Engineers, Australia, and the University of Melbourne. The City of Melbourne is known as the Garden City and is located in the State of Victoria, the southernmost and smallest state in Australia. It has a population of about 3 million. The University is Victoria's first, founded in 1853. It is situated on 19 hectares of land about 2 km north of the city. Total enrollment is about 16,000 students. Hotel accommodations were available within walking

distance of the campus and meeting rooms. Midday meals were available at the nearby local Union Building on campus.

4. Meeting rooms were adequate and fully equipped with audiovisual equipment. All presentations were in English with the exception of one series of papers when both French and English translations were provided. Six volumes of the preprinted proceedings were provided each participant upon registration. I mailed my copies back to the US Army Engineer Waterways Experiment Station (WES) for library accession and general use.

#### Attendance

5. The attendance was estimated to be about 400, which is down from previous Congresses. This can probably be attributed to the great travel distances for European and North and South American members. As to be expected, Australians and New Zealanders dominated the registrants. The United States was represented by 20 attendees, most of whom were from academic institutions. There was one representative from the Tennessee Valley Authority, one from the US Geological Survey, and three from WES (Mr. Steven C. Wilhelms, Dr. Todd L. Walton, Jr., and I). A list of registrants to 23 August and the organizations which they represented are shown in Appendix B. The US registrants are underlined.

#### Program

6. The overall Congress theme was "Hydraulic Research for Water Management in the Eighties." Actual subjects selected for discussion were:

- a. Subsurface Flow, Pollutant Transport, and Salinity.
- b. Free Surface Hydraulics and Water Management.
- c. Flows and Sediments in Harbors and Inlets.
- d. Flow Measurement and Data Acquisition.

Technical sessions were held from 0900 to 1730, Monday through Friday, with the number of sessions per day varying from three to six. The detailed technical program is included as Appendix C.

7. Four half-day seminars also were conducted during the Congress. These covered such subjects as urban drainage, hydraulic structures, hydraulic transients, and small hydropower generation.

8. The opening session on Monday was quite formal. In deference to possible disturbances, there was no general display of flags on the stage as in past Congresses. Following the Australian national anthem and remarks by E. J. Plate, President of IAHR, and Prof. Sir Douglas Wright, Chancellor of



the University of Melbourne, a presentation to the combined group was made by His Excellency, the Administrator of the Commonwealth of Australia, Sir James Rowland. The technical sessions were opened by the keynote speaker, Prof. G. Garbrecht, speaking on 5,000 years of hydraulic engineering. A copy of the opening program is attached as Appendix D. President Plate announced that T. Hayashi of Japan, H. Rouse of the United States, and M. Hug of France had been elected to Honorary Membership in the association.

9. Mr. Wilhelm's paper was given on Tuesday as part of Session 6. His paper, coauthored with Holland and Smith, and entitled "Advances in Selective Withdrawal Through a Point Sink," was well received. Dr. Walton's paper was presented on Thursday as part of Session 10. His paper was coauthored by Douglass and entitled "Stochastic Sand Transport Synthesis Using ARIMA Modeling." Generally all the papers in a session were reviewed by a General Reporter after which the author expanded on the remarks and answered questions. Many of the presentations by the General Reporters were difficult to follow because of the foreign accents. A novel timer used at each session involved the use of a float in a cylinder filled with water. An orifice in the base of the float caused it to sink in some predetermined time interval. It was effective in controlling the session lengths.

10. At the closing session the following members were elected to the Council to serve for the year 1986-87:

President	E. J. Plate, Germany
Vice Presidents	R. A. Elder, USA Y. Iwasa, Japan J. D. Lawson, Australia
Secretary/Treasurer	J. E. Prins, Netherlands
Members	J. P. Benque, France T. M. Dick, Canada J. J. Garcia, Venezuela R. J. Garde, India W. H. Graf, Switzerland V. Ya Karelin, USSR O. Starosolszky, Hungary

It was announced that the Twenty-second Congress would be held at Lausanne, Switzerland, from 31 August to 4 September 1987.

### Comments

11. The Australian engineers made every effort to put on a good Congress. The technical programs were excellent as were most of the arrangements. The ladies' programs and outside tours also were appreciated by everyone. It was evident, however, that the group had little previous experience in fielding large international conferences. Minor unexpected problems frequently surfaced. Some of the participants had to change hotels because of advance reservation problems. At the closing banquet, one of the hotel pickup points was overlooked, and about 100 participants were stranded for about an hour; then the bus driver could not find the site of the banquet. However, one can judge it a successful Congress.

12. Attendance at the meeting permitted the renewal of old friendships and making of new ones, particularly with representatives from foreign laboratories. The opportunity to exchange ideas on common problems is considered invaluable. The technical program was the catalyst for such exchanges. Careful review of the proceedings should document the value of the technical papers and indicate possible new advances.

13. Australia is a young country with 90 percent of the 15 million population concentrated along the eastern seaboard. It is a land of extremes with lush garden spots and vast desert areas. The coastline is longer than that of the United States, and it has all the coastal problems experienced by this country. Water availability and water management are troublesome, particularly in the interior. Pollution and the environment are increasing problems. The Australian engineers are aware of the problems and are addressing them as resources permit. However, it is believed their technology is about 10 years behind the general state of the art as we know it in the United States. Hydraulic laboratory facilities are available for physical models at the University of Melbourne and at a site on the outskirts of Melbourne (Appendix E).

### Post-Congress Technical Tour

14. I departed Melbourne on 24 August on one of the four post-Congress tours offered. I selected Tour 1, which was 6 days long. Travel to Alice Springs, Ayers Rock, and Sydney was by air. Ayers Rock is the world's largest monolith, located in the dry center of Australia about 400 km southwest of Alice Springs. It is one of the most isolated areas of the world with an

annual rainfall of 250 mm. The monolith measures about 3 km long, 2.5 km wide, and 335 m high. Aboriginal paintings and caves illustrate ancient tribal legends. Aborigine people also inhabit the general area of Uluru National Park in which it is located. On the park's boundary is a tourist resort, Yulara, which is a self-contained vacation area for visitors. A tour of the resort's power station desalination works (electrodialysis essential in the arid climate of the area), solar energy operations, and wastewater treatment works was made. Technical details were provided in handout material.

15. After 2 days at Ayers Rock, I returned to Alice Springs. This area, located in the geographical center of the continent, was opened in 1872 as a repeater station for the overland telegraph linking northern and southern Australia. In 1929 when it was joined to the south with a railroad, the population was only 200. Now its population totals about 40,000. The town's utilities and the Royal Flying Doctors Base headquarters were toured. My fellow participants in Tour 1 were Messrs. Iwasa, Ito, and Ogihara of Japan, Mr. Preston of New Zealand, Mr. McKenzie of Australia, Mr. Leutheusser of Canada, plus a guide from Sydney provided by the Congress. All were accompanied by their wives except for Messrs. Ogihara and McKenzie.

16. I arrived at Sydney on 27 August and left for Auckland, New Zealand, on 28 August. One never forgets Australia because of the \$22 departure tax.

#### New Zealand Tour

17. New Zealand consists of two large islands (North Island and South Island) and numerous small islands. It has a total population of 3 million people and 75 million sheep. Of the 3 million people, 800,000 are located in Auckland, which lies about 1,300 air miles east of Sydney. It is a mixed culture of English and Maoris and truly a sportsman's paradise.

18. My wife and I joined a tour by bus of the North Island on 29 and 30 August. We traveled through the town of Hamilton and dairy country to Waitomo and the glowworm caves. Then we went on to Rotorua and its boiling mud pools and geysers at the thermal reserve. Of interest was the use of geothermal areas as a source of energy. We also visited Arapuni Dam on the Waikato River. The dam is a concrete arch about 210 ft high. Power is generated by passing flow through 12-ft-diameter penstocks. A sheep shearing demonstration also was observed near Rotorua.

19. On 31 August we traveled to Queenstown by air and joined another bus tour of the South Island. We traveled through magnificent mountain scenery to Milford Sound where a launch cruise was made along the 10-mile waterway to the sea entrance. We were told the area had rain 340 days per year but we experienced only sunshine. We then continued on to the southern tip of the island at Bluff, back up the east coast to Dunedin, and on to Mount Cook. En route we inspected the hydroelectric development in the upper Waitaki and Mackenzie areas. A stop was made at the Benmore Dam. Descriptive material is attached as Appendix F. We arrived at Mount Cook on 4 September in the rain which later changed to snow. However, we left next day on schedule past Lake Pukcki and completed the tour at Christchurch on 5 September. We left Christchurch on 6 September for Auckland where we caught a New Zealand flight for Tahiti in French Polynesia that night. New Zealand Air was used for intercontinental travel because stops en route were permitted without an increase in fare.

#### Tahiti

20. Because of the international date line and time changes, we arrived in Papeete on 6 September and left the same day for the island of Huahine. These volcanic islands are part of the Society group and are located 3,700 miles from San Francisco and 2,400 miles south of Honolulu. Tahiti is the largest island and Papeete is the capital. Rugged mountains, blue water, white and black sand beaches, and unspoiled beauty have made Tahiti an ideal tourist retreat. The island of Huahine is located approximately 80 miles northwest of Tahiti and is a perfect place for those looking for seclusion and natural beauty. The Hotel Bali Hai is the only hotel on the island and offers thatched roof bungalows in a lush tropical setting. The beaches are of white sand but are not very large. The island has been open for tourism only for about 10 years. We left Huahine on 8 September for Bora Bora.

21. The trip to the Bora Bora Hotel consists of a 50-minute flight, a 40-minute boat ride to the village of Vaitape, and then a 6-mile bus ride. James Michener wrote that Bora Bora was the "most beautiful island in the world." We agree. The lush vegetation, hibiscus blossoms, sparkling white sand beaches, and crystal clear water of a large circular coral lagoon cannot be surpassed. Only 3,500 people live on the island and life is peaceful and slow. The absence of newspapers or TV cuts one off from the problems of the

world. We spent a restful 4 days before returning to the United States.

22. We left Bora Bora for Papeete on 12 September and boarded a plane for Los Angeles on 13 September, arriving there the same day. Thus ended an excellent educational and pleasure trip.

FRED R. BROWN



DEPARTMENT OF THE ARMY

U.S. Army Corps of Engineers

WASHINGTON, D.C. 20314-1000

June 21, 1985

REPLY TO  
ATTENTION OF:

Office of Travel and Transportation

SUBJECT: Invitational Travel Order I85-377

Mr. Frederick R. Brown  
105 Stonewall Road  
Vicksburg, Mississippi 39180

Dear Mr. Brown:

You are invited to proceed from your place of business and/or residence in sufficient time to arrive in Melbourne, Australia, on or about August 18, 1985. The purpose of this mission is to permit you to obtain state-of-the-art knowledge the field of hydraulics on Worldwide basis for application by the Corp. The period of this mission is approximately six (6) days. Upon completion of this mission, you will be reimbursed for expenses incurred in returning directly to point of origin.

Travel by rail, commercial or military aircraft, bus, and privately-owned-automobile is authorized. You are advised that the Department of Defense policy requires that in using regularly scheduled air transportation, accommodations selected will be the least costly service which will permit satisfactory accomplishment of the mission of the traveler.

If practicable, you will be provided a Government Transportation Request to exchange for carrier tickets. If transportation request is not used and travel is performed by common carrier at personal expense, reimbursement for the cost of transportation will be limited to:

a. The least costly, regularly scheduled air service between the points involved, or the lowest cost class of accommodations available at the time reservations were made.

b. The cost of the rail fare and lower berth, or the lowest first class rail accommodations available at the time reservations were made.

c. Actual cost of commercial bus fare.

If you travel by privately-owned-automobile, reimbursement will be authorized at the rate of .20¢ cents per mile, plus the cost of necessary parking fees, bridge, ferry, and other highway tolls incurred while in a travel status

under this travel order. The total reimbursement will be limited to the cost of travel by the usual mode of common carrier including per diem. Receipts and ticket stubs will be required to substantiate your claim for cost of transportation and subsistence for items in excess of \$15.00.

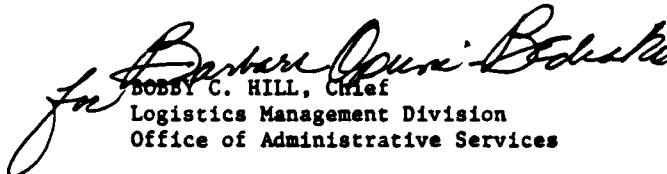
Normally you will be entitled to a per diem allowance to cover your expenses for lodging, meals, and incidentals. While traveling and performing the mission within the continental United States, you will be authorized a per diem equal to the daily average amounts you pay for lodging, plus \$23 per day for meals and incidentals, rounded off to the next dollar. If the resulting amount is more than the maximum per diem allowable which is \$50, then only the maximum per diem will be authorized.

For the purpose of reimbursement, you are required to state on your reimbursement voucher that the per diem claimed is based on the average cost to you for lodging while on official travel within the continental United States during the period covered by the voucher. Receipts are required for lodging. The per diem allowance for travel overseas is based on rates established by the Department of State or by the Department of Defense. Accordingly, you will be authorized the amount specified for the particular overseas area involved.

Address any inquiries and submit voucher to U. S. Army Corps of Engineers, Waterways Experiment Station, P.O. Box 631, Vicksburg, Mississippi 39180-0631.

The travel herein has been determined to be in the public interest and is chargeable to: Appropriation No. 2152020, Operation and Maintenance, Army, WES Job Number QE5V020V117@001.

Sincerely,

  
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## THE CONGRESS PROGRAM – DETAILED SCHEDULE

### SUNDAY 18 AUGUST 1985

1400-1900 Registration – Logic Classroom, Old Arts Building

### MONDAY 19 AUGUST 1985

0800-0900 Registration – Logic Classroom, Old Arts Building

0900-1030 Plenary Session

Location: Wilson Hall

Opening ceremony

Opening: His Excellency AIR MARSHALL SIR JAMES ROWLAND, K.B.E., D.F.C., A.F.C., Administrator of the Government of the Commonwealth of Australia.

Keynote Address, Professor Dr-Ing. G. GARBRECHT

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1030-1100 Morning Tea

1100-1230 Technical Session 1

Technical Session 1A – 1100-1230 Monday 19th August 1985

Sub-theme A.(a) – Modelling of recharge and sub-surface flows

Location: Public Lecture Theatre

Chairman: Dr. C. R. Dudgeon, University of New South Wales

Session Organizer: Mr. R. C. Lahey, Dept. of Minerals & Energy, Vic.

Presentation by General Reporter, Assoc. Prof. R.E. VOLKER, James Cook University, Qld.

Simultaneous translation provided

Papers (Proceedings Volume 1):

BONNETON, JARDIN, LAVEDAN & MOULLARD: "The MINOS Model Two-Dimensional Representation of Subsurface Flow in Saturated and Unsaturated Zones."

EDENHOFER & SCHMITZ: "Analytical Solution of the Infiltration Equation."

JAYAWARDENA: "Moisture Movement Through Unsaturated Porous Media: Numerical Modelling, Calibration and Application."

LIGGETT & DILLON: "A Dynamic Model of Flow Exchange Between Streams and Aquifers."

SCHMITZ, HAVERKAMP & PALACIOS: "A Coupled Surface-Subsurface Model for Shallow Water Flow Over Initially Dry Soil."

SEGURA & YEVJEVICH: "Stochastic Modelling of Groundwater Recharge."

STAUFFER & DRACOS: "An Advective Transport Model for Recharge Studies in Layered Soils."

TOWNLEY: "Response of Shallow Aquifer Systems to Periodic Recharge."

USSENKO: "Groundwater Flow Estimates for Artificial Groundwater Systems."

Technical Session 1B – 1100-1230 Monday 19th August 1985

Sub-theme B.(a) – Fundamental aspects of free surface flows

Location: Theatre B

Chairman: Prof. Ben Chie Yen, University of Illinois  
Session Organizer: Dr. I. O'Neill, University of Melbourne  
Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 2):

VOLKART: "Transition from Aerated Supercritical to Subcritical Flow and Associated De-aeration."

ANISTIS & CHU: "Entrapment Characteristics in a Recirculating Eddy"

FUKUOKA & YAMASAKA: "Equilibrium Wave Height and Flow on Alternate Bar Based on Non-Linear Relationships of Bedform, Flow and Sediment Discharge."

KERESELDZE & MUZAEV: "Theoretical and Numerical Solutions of Some Problems Associated with Wave Motion in Rivers, Water-Pools and Reservoirs."

FENTON: "A Family of Stable Explicit Schemes for Computational Hydraulics."

1230-1400 Lunch

1400-1530 Technical Session 2

Technical Session 2A - 1400-1530 Monday 19th August 1985

Sub-theme A.(a) Natural and artificial groundwater recharge

Location: Theatre B

Chairman: Dr. T. Dracos, Federal Institute of Technology, Switzerland

Co-chairman: Dr. L. Townley, University of Western Australia

Session Organizer: Mr. J.G. Leonard, Dept. of Minerals and Energy, Vic.

Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 1):

AKAN & YEN: "Groundwater Recharge From Overland Flow"

PEREZ-FRANCO: "The Nonlinear Approach of Groundwater Hydraulics as Applied to Artificial Recharge Through Wells."

SHARMA, CRESSWELL & WATSON: "Estimates of Natural Groundwater Recharge from the Depth Distribution of an Applied Tracer."

VISWANATHAN: "Estimation of Natural Recharge in an Unconfined Aquifer."

WILLIAMS: "Hydrogeology and Hydrochemistry of Natural and Induced Recharge of the Unconsolidated Sediments of the Lower Namoi Valley with References to the Effect of Artificial Recharge."

Technical Session 2B 1400-1530 Monday 19th August 1985

Sub-theme B.(a) - Numerical computation of 2-D and 3-D flows

Location: Public Lecture Theatre

Chairman: Dr. B. Westrich, University of Stuttgart

Session Organizer: Dr. I. O'Neill, University of Melbourne

Presentation by General Reporter, Dr D.R. BLACKMAN, Monash University

Simultaneous translation provided

Papers (Proceedings Volume 2):

BENQUE, DALSECCO & ESPOSITO: "Une Methode d'Elements Finis Pour le Calcul de Mares et de Surcotes."

CARBALLADA: "Steady 2-D Linear and Non-Linear Model."

GOPALAKRISHNAN, TUNG & WEI: "A Numerical Model for Computing Storm Surge Flooding Extent."

KANSOH: "Numerical Prediction for Two Dimensional Flow in Open Channels."

MCCOWAN: "Equation Systems for Modelling Dispersive Flow in Shallow Water."

MISHUEV, SLADKEVICH & CHUMAKOV: "The Propagation of the Shock Wave in the Trapezoidal Channel."

ROGOUNOVICH & SHNIPOV: "Calculation of Cross-flows in straight Rectangular and Trapezoidal Ducts with Variable Peripheral Roughness."

SIEGERSTETTER, MICHEL & FRANKE: "Numerical Solution of Flow Around Objects — Are Super-computers the Answer?"

TAMAI & IKEYA: "A Mathematical Model of a Three-Dimensional Flow Over Bars in Meandering Channels."

WOLANSKI: "Numerical Modelling of Flow in a Tidal Creek — Mangrove Swamp System."

Seminar (b) Guidelines for the design of hydraulic structures — cavitation, dynamic forces, vibration

Location: Seminar Room

Session Organizers: Prof. A. Raudkivi, University of Auckland and Mr. K.A. Murley, Rural Water Commission

Lead Papers: R.E.A. ARNDT:

"Cavitation"

E.J. LESLEIGHTER:

"Flow-induced Vibrations"

J.B. HINWOOD & R.J. KELLER: "Hydrodynamic Forces"

The above are position papers on Monographs A4, A3 & A2 respectively for the IAHR Hydraulic Structures Design Manual.

Other papers by various authors available at the door.

Simultaneous translation not provided

1530-1600

Afternoon Tea

1600-1730

Technical Session 3

Technical Session 3A — 1600-1730 Monday 19th August 1985

Sub-theme A(c) — Natural flows in regional-scale deep aquifers

Location: Theatre B

Chairman: Dr. C. Lawrence, Dept. of Minerals and Energy, Vic.

Session Organizer: Mr. C. Lahey, Dept. of Minerals and Energy, Vic.

Presentation by General Reporter, Mr S.J. HANCOCK, Australian Groundwater Consultants

Simultaneous translation not provided

Papers (Proceedings Volume 1):

AGBEDE & ARUMUGAM: "Mathematical Modelling of Deep Aquifers in Northern Nigeria."

BLACK & WOOLARD: "Measurement of Flows from the Mound Springs of the Great Artesian Basin."

DUDGEON: "The Validity of Darcy's Law in Low Shear-rate Flows in Aquifers."

KHADER & RAMADURGAIAH: "Flow Into a Well in Bounded Leaky Artesian Aquifers"

MICHIUE, SUZUKI & HINOKIDANI: "Unsteady Flow of Unconfined Groundwater in an Alluvial Plain."

SATO, YAMASAKI, KAMATA & FUJISAKI: "A Numerical Approach to Total Control System of Groundwater Resources in Saitama Basin."

van WONDEREN & DOTTRIDGE: "Simulation of Regional Groundwater



Flow Using Digital Models and Their Application to Planning of Ground-water Development."

Technical Session 3B – 1600-1730 Monday 19th August 1985

Sub-theme B.(a) – Numerical computation of 2-D and 3-D flows

Location: Public Lecture Theatre

Chairman: Dr. T. Tingsanchali, Asian Institute of Technology

Session Organizer: Dr. A.H.F. Wong, Gutteridge, Haskins and Davey

Presentation by General Reporter, Prof. Y. IWASA, Kyoto University

Simultaneous translation provided

Papers (Proceedings Volume 2):

CHAO-LIN CHIU & JYH-DONG CHIOU: "Flow-Shear Interaction in Rectangular Open Channels."

CHENIN-MORDOJOVITCH & HAUGUEL: "The Internal Refined Grid in Particular Areas Inside a Two-Dimensional Mathematical Model."

GVAZAVA, SHARIKADZE & OBGADZE: "Numerical Method of Solution of a Two-Dimensional Problem of Viscous Flow Around Solids Applied for Design of Fixing Members of Some Hydraulic Structures."

KALKWIJK & KOPPEL: "Experiments on Unsteady Separating Flow in an Open Channel."

MENDOZA & SHEN: "Steady Two-Dimensional Flow Over Dunes."

NEZU & RODI: "Experimental Study on Secondary Currents in Open Channel Flow."

PAVLOVIC & RODI: "Depth-Average Numerical Predictions of Velocity and Concentration Fields in Meandering Channels."

PRZEDWOJSKI: "Bed Topography in Circular Bend."

WIJBENGA: "Determination of Flow Patterns in Rivers with Curvilinear Coordinates."

Seminar (b) Guidelines for the design of hydraulic structures – cavitation, dynamic forces, vibration (continued).

Location: Seminar Room

Evening: State Reception (Delegates and accompanying persons.)

## **TUESDAY 20 AUGUST 1985**

0830-0900 Registration – Logic Classroom, Old Arts Building

0900-1015 Plenary Session

Location: Wilson Hall

Keynote Address: Prof. I. R. WOOD, University of Canterbury: "Air Water Flows".

Address by Recipient of the Ippen Award: Prof. K.G. Ranga Raju, University of Roorkee: "Transport of Sediment Mixtures."

1015-1030 FLOMEKO '85 Opening Ceremony

Location: Wilson Hall

1030-1100 Morning Tea

1100-1230 Technical Session 4

Technical Session 4A – 1100-1230 Tuesday 20th August 1985

Sub-theme A.(d) – Groundwater movement in relation to land and water salination and soil consolidation

Location: Theatre B

Chairman: Dr. M. L. Sharma, CSIRO

Co-chairman: Dr. M.H. Abdul Khader, University of Singapore

Session Organizer: Mr. J.G. Leonard, Dept. of Minerals and Energy, Vic.

**Presentation by Authors**

Simultaneous translation not provided

**Papers (Proceedings Volume 1):**

BOOKER, SMALL & CARTER: "Prediction of Subsidence Caused by Pumping of Groundwater."

VOLKER & MARINO: "Effects on the Salt Water Interface of Groundwater Pumping on Ocean Atolls."

DAS GUPTA & DE MEL: "Multi-Layer Solute Transport Model and Its Application."

IFE & TREWHELLA: "Estimates of the Groundwater Budget of an Irrigated Region near Shepparton, Australia."

MYNAREK: "Design Geotextiles as Protective Filters."

Technical Session 4B - 1100-1230 Tuesday 20th August 1985

Sub-theme B.(c) - Transport and mixing in rivers and reservoirs

Location: Lecture Theatre C

Chairman: Prof. N. Rajaratnam, University of Alberta

Co-chairman: Dipl.-Ing P. Hanscheid, RWTH, Aachen.

Session Organizer: Mr. W.T. Wong, Monash University

Presentation by Authors

Simultaneous translation not provided

**Papers (Proceedings Volume 2):**

ABDEL-GAWAD & McCORQUODALE: "Initial Mixing of Cross Flowing Jets in Trapezoidal Channels."

GERARD, PUTZ & SMITH: "Mixing Downstream of a Small Bank Outfall in a Large Northern Stream."

JOHNSTON: "Aspects of Buoyant and Non-buoyant Jets Entering Shallow Tailwaters."

D'ANDREA & BADDOUR: "The Turbulent Domain of an Unconfined Surface Thermal Plume."

TIPLER: "The Controlled Discharge of Chemically Treated Meatworks Effluent to the Waimakariri River."

Technical Session 4D jointly with FLOMEKO '85 - 1100-1230 Tuesday 20th August 1985

Sub-theme D.(d) - Laboratory measurement and instrumentation Location:

Public Lecture Theatre Chairman: Dr. E.A. Spencer, IMEKO

Co-chairman: Dr. B.B. Sharp, University of Melbourne

Session Organizer: Dr. H.R. Graze, University of Melbourne

Presentation by General Reporter, Prof. F. DURST, University of Erlangen

Simultaneous translation provided

**Papers (Proceedings Volume 5):**

BARCZEWSKI: "Development of a Laser-Fluorometer for Sensitive, Local Concentration Measurements in Flows."

BROWAND & PLOCHER: "Image Processing for Sediment Transport."

GULLIVER: "Open Channel Flow Measurements in a Moving-Bed Flume."

HAENSCHIED, KIRSCHBAUER & ROUVE: "Image Processing - A Modern Flow Measurement Technique."

LEGONO & RAO: "Velocity Distribution Across the Width of a Rectangular Open Channel as Revealed by the Laser Doppler Anemometer."

MUELLER: "A Three Component LDA Tested in the Mixing Layer Behind Dunes."

ODGAARD: "Measurements of Secondary Currents in Curved, Movable-

Bed Channel."

OESCH, BURRY & SCHNEITER: "Leves Topographiques Par Moire Sur Modeles A Fonds Mobiles."

PLATE, MAIER-ERBACHER & FREIDRICH: "The Effects of a Wall on Turbulent Flow. A Comparison of Laboratory Experiments with Wind and Water Flow over Rough Boundaries."

VASILCHENKO: "Velocity Measurements at Rough Water-Permeable Flow Boundaries."

1230-1400 Lunch

1400-1530 Technical Session 5

Technical Session 5A - 1400-1530 Tuesday 20th August 1985

Sub-theme A.(b) - Pollutant transport in aquifer flows

Location: Public Lecture Theatre

Chairman: Mr. A.K. Turner, University of Melbourne

Co-chairman: Dr. A. Das Gupta, Asian Institute of Technology

Session Organizer: Mr. R.C. Lahey, Dept. of Minerals and Energy, Vic.

Presentation by Authors

Simultaneous translation provided

Papers (Proceedings Volume 1):

ROWE & BOOKER: "Pollutant Transport Through Clayey Soils and Underlying Aquifers."

BRILLY: "A Dual Porosity and Hydrodynamic Dispersion in the Direction of Flow in Porous Media."

KOBUS & SPITZ: "Transverse Mixing of Stratified Flows in Porous Media."

BARBER & DAVIS: "Groundwater Quality Monitoring: Representative Sampling from Boreholes to Determine Variations in Quality with Depth and Time."

Technical Session 5B - 1400-1530 Tuesday 20th August 1985

Sub-theme B.(c) - Mixing processes in rivers and reservoirs

Location: Theatre C

Chairman: Dr. B. Barczewski, University of Stuttgart

Session Organizer: Mr. A.D. McCowan, Lawson and Treloar Pty. Ltd.

Presentation by General Reporter, Dr I.G. WALLIS, Consulting Environmental Engineers

Simultaneous translation not provided

Papers (Proceedings Volume 2):

ARNOLD, PASCHE & ROUVE: "Mixing in Rivers with Compound Cross-Section."

CHAPMAN: "Time of Travel Studies in the Yarra River."

IWASA & AYA: "Lagrangian Characteristics of Longitudinal Mixing in Free Surface Shear Flows."

LAWRENCE: "Mixing in Steady Two-layer Flow Over Topography."

MAXWORTHY & MONISMITH: "Differential Deepening of a Mixed Layer in a Stratified Fluid."

NOKES: "Dispersion of Buoyant Particles in Two-Dimensional Turbulent Open Channel Flow."

PHILIPS: "Circulation and Mixing Characteristics in a Service Reservoir."

PLATE, FRIEDRICH & DITTRICH: "Wind and Flow Induced Mixing in Rivers and Reservoirs: The Effect On Reseration."

TAUS: "Mixing Processes in Lakes Following the Discharge of Sewage Water."

VUKELIC: "Degree of Mixing of Pollutants in the Vardar River Through the Area of the City of Skopje as a Function of the Probability."

Technical Session 5D - 1400-1530 Tuesday 20th August 1985

Sub-Theme D.(a) - Flow measuring techniques for rivers and lakes

Location: Theatre B

Chairman: Dr. T. Milne Dick, National Water Research Institute, Canada

Co-chairman: Dr. J.J. Peters, Ministry of Public Works, Belgium

Session Organizer: Dr. H.R. Graze, University of Melbourne

Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 5):

BILLFALK & DAHLBACK: "The Use of a Telemetric Computer-controlled System for Water Level Measurements."

MUSZKALAY & STAROSOLSZKY: "Two- and Three-Dimensional Flow Metering in Large Rivers."

ASANO, YOSHINO & HAYAKAWA: "Improvement of Accuracy of Flow Measurement Technique in Alluvial Rivers."

LAMMEL & VALENTIN: "Field Measurements in the Mixing Region Between River Inflow and Lake."

FISHER: "Inexpensive Instrumentation for Measurement of Low Velocities in Shallow Lakes."

FLOMEKO '85 Session - 1400-1600 Tuesday 20th August 1985

General (including Turbine Flow)

Location: Theatre A

Chairman: Dr. F. C. Kinghorn

Co-chairman: Dr. D. B. Prowse

Presentation by Authors

Simultaneous translation not provided

Papers:

MATTINGLEY: "Prospects for Improvements in Fluid Metering Via New Research Tools."

SALAMI & HUTTON: "Development of a Turbine Flowmeter Calibration Rig."

SIENICKI & BAKER: "Using Microcomputer Technology to Improve Flow Measurement Accuracy in the Petroleum Industry."

JELFFS & HAYWARD: "Developments in the Accurate Metering of Natural Gas Liquids."

1530-1600 Afternoon Tea

Poster Paper Session (Authors present)

Location: Corridors, Old Arts Building

1600-1730 Technical Session 6

Technical Session 6A - 1600-1730 Tuesday 20th August 1985

Sub-theme A.(b) - Pollutant transport in aquifer flows

Location: Public Lecture Theatre

Chairman: Dr. R. Habermehl, Bureau of Mineral Resources, Australia

Session Organizer: Mr. J.G. Leonard, Dept. of Minerals and Energy, Vic.

Presentation by General Reporter, Assoc. Prof. K.K. WATSON, University of New South Wales

Simultaneous translation provided

Papers (Proceedings Volume 1):

AMER & BAZARAA: "Hydrothermal Impacts of Salt Gradient Solar Ponds on the Surrounding Soil. A Discrete Kernel Approach For Unlined Ponds."

MERKEL, SCHMITZ & HAVERKAMP: "Temperature Affected Pollutant Transport Phenomena in Unsaturated Soil."

MINKIN, KUTATELADZE, KAVTUASHVILI & BESELYA: "Transport Equations of Non-conservative Impurities and Their Solution for an Aquifer."

OLEINIK, TELIMA & SIRIY: "Numerical Simulation of the Moisture and the Salts Motion While Studying the Transfer of the Contaminant Substances and Dissolution of the Soils."

PELKA & DORGARTEN: "Nonconservative Pollutant Transport in Saturated-Unsaturated Groundwater Flow."

SATO, SHIMIZU & ITO: "Applied Study On Pollutant and Heat Diffusion Around Underground Cavern."

Technical Session 6B – 1600-1730 Tuesday 20th August 1985

Sub-theme B.(c) – Stratified flows and selective withdrawal in rivers and reservoirs

Location: Theatre C

Chairman: Prof. E. Plate, University of Karlsruhe

Session Organizer: Mr. A. D. McCowan, Lawson and Treloar Pty. Ltd.

Presentation by General Reporter, Assoc. Prof. D. WILKINSON, University of New South Wales

Simultaneous translation not provided

Papers (Proceedings Volume 2):

DELVIGNE: "A Model for Vertical Diffusion in Stratified Shear Flows."

DENTON: "Density Current Inflows to Run of the River Reservoirs."

HIRATA & MURAOKA: "Internal Wave and Temperature Microstructure in Thermally Stratified Lakes."

IWASA & INOUE: "Mathematical Simulation of Plane and Multi-Layer Flows in a Large and Deep Lake."

KRANENBURG: "Laboratory Experiments on Mixed-layer Deepening in Water Bodies of Limited Extent."

MEARES: "Hydrodynamic Aspects of the Treatment of Water in an Open Cut Using a NonMixing Cycle."

SPIGEL & OGILVIE: "Importance of Selective Withdrawal in Reservoirs With Short Residence Times: A Case Study."

WILHELMS, HOLLAND & SMITH: "Advances in Selective Withdrawal Through a Point Sink."

FLOMEKO '85 Session – 1630-1830 Tuesday 20th August 1985

Electromagnetic and Vortex Flow

Location: Theatre A

Chairman: Dr. R. B. Mottram

Co-chairman: Mr. P. Sharpin

Presentation by Authors

Simultaneous translation not provided

Papers:

KINGHORN, MacLEAN, EBERLE & KALKHOF: "The Use of Electromagnetic Flowmeters as Transfer Standards."

JOHN & JOHNSON: "Streamflow Measurement Reviewed with Emphasis on Two Lesser-Used Approaches."

SOTNIKOV & MURZIN: "Comparison Studies of Flowmeter Calibration Procedures Using Weighing Technique."

LUCAS & TURNER: "Influence of Cylinder Geometry on the Quality of Its Vortex Shedding Signal."

BENTLEY: "The Development of a Vortex Flowmeter for Gas Flows in Large Ducts."

Evening: Evening free

**WEDNESDAY 21 AUGUST 1985**

0830-0900 Registration - Logic Classroom, Old Arts Building

0900-1030 Technical Session 7

Technical Session 7B - 0900-1030 Wednesday 21st August 1985

Sub-theme B.(c) - Numerical modelling of transport and mixing in rivers and reservoirs

Location: Public Lecture Theatre

Chairman: Dr-Ing B. Barczewski, University of Stuttgart

Session Organizer: Prof. B.B. Willetts, University of Aberdeen

Presentation by General Reporter, Prof. W. RODI, University of Karlsruhe

Simultaneous translation provided

Papers (Proceedings Volume 2):

BECHTELER & SCHRIMPF: "A Numerical Calculation for the Deposition of Fine Sediment in Horizontal Settling Basins."

BELLEUDY & SAUVAGET: "A New System for Modelling Pollutant Transport in River and Canal Networks."

CZERNUSZENKO: "Transport and Dispersion in Rivers."

FORURIA, SIVAKUMAR & VOLKER: "A Simulation Model for Management of Water Quality in a Water Supply Reservoir."

HOLLY & TODA: "Hybrid Numerical Schemes for Linear and Nonlinear Advection."

JOKELA & PATTERSON: "Quasi Two-Dimensional Modelling of Reservoir Inflow."

KEILLER & CLOSE: "Modelling Salt Transport in a Long River System".

KUO & CHEN: "Unsteady Hydraulic and Water Quality Modeling for a River-Estuarine System."

MUROTA & MICHIOKU: "Field Observation and Numerical Modelling of Thermal Structure in a Pumped Storage Reservoir."

Technical Session 7D jointly with FLOMEKO '85 - 0900-1030 Wednesday 21st August 1985

Sub-theme D.(c) - Laboratory measurement; unsteady flow measurement

Location: Theatre A

Chairman: Dr. B.A. Christensen, University of Florida

Co-chairman: Dr. B.B. Sharp, University of Melbourne

Session Organizer: Dr. H.R. Graze, University of Melbourne

Presentation by General Reporter, Prof. C. APELT, University of Queensland

Simultaneous translation not provided

Papers (Proceedings Volume 5):

ABDEL-GAWAD, HANNOURA & McCORQUODALE: "Rapidly Accelerated Flow Past Multiple Obstructions."

BEGUIN & SCHNEITER: "Automatic Measurement of Water Level."

BRITTON, DRUERY & FLOYD: "Flow Measurement and Data Acquisition Port Hacking, NSW, Australia."

CASH: "Practical Aspects of Computerised Real Time Automatic Control and Data Acquisition of a Large, Dynamic, Multi-Tributary Tidal Flood Plain Physical Model."

ISAACSON: "Laboratory Measurement and Generation of Multi-Directional Surface Waves."

JOHNSTON: "Turbulent Shear Stress Measurement Using Hot-Film Anemometry."

LEVIN & LOPATIN: "Straightening of Velocity Profiles and Decrease of Turbulence Intensity by Confusers."

MULLE & HOPWOOD: "Video Tape Recording of Float Tracks and Velocities in Hydraulic Model Studies."

OGIHARA: "A Proposal on Extended Reynolds Number."

RAO & HALL: "An Experimental study of the Development of Turbulence in Open Channels."

SALAMI: "Problems in Prediction of Prototype Performance of Large Axial Flow Fans From Model Tests."

Seminar (a) Urban drainage hydraulics

Location: Seminar Room

Seminar Organizers: Prof. E.M. Laurenson, Assoc. Prof. R.G. Mein, Monash University

Lead Papers (Proceedings Volume 6):

T. MILNE DICK & J. MARSALEK: "Manhole Head Losses in Drainage Hydraulics."

M.J. BOYD: "Stage-Discharge Relations for Culverts and Outlets."

Other Papers by various authors available at door

Simultaneous translation not provided

1030-1100

1100-1230

Morning tea

Technical Session 8

Technical Session 8B - 1100-1230 Wednesday 21st August 1985

Sub-theme B.(c) - Transport and mixing in rivers and reservoirs

Location: Public Lecture Theatre

Chairman: Prof. H. Kobus, University of Stuttgart

Co-chairman: Dr-Ing B. Westrich, University of Stuttgart

Session Organizer: Prof. B.B. Willems, University of Aberdeen

Presentation by Authors

Simultaneous translation provided

Papers (Proceedings Volume 2):

SHARP & HERAT: "Dynamic River Bend Flow Observations."

TSANIS & LEUTHEUSSER: "Experiments on Simulated Wind-Induced Water Currents."

PRASUHN & KNOFVZYNSKI: "Improved Computation of Fall Velocity."

FONCK, GRILLI, LEJEUNE & SAHLOUL: "Open Channel Hydraulics and Water Management."

Technical Session 8C - 1100-1230 Wednesday 21st August 1985

Sub-Theme C.(c) - Stability of tidal inlets and coastal structures, control of tidal flows

Location: Public Lecture Theatre

Chairman: Mr. F. Biesel, Consultant, France

Session Organizer: Mr. D. L. Reid, Monash University

Presentation by General Reporter, Mr B. DRUERY, Dept. of Public Works, N.S.W.

Simultaneous translation provided

Papers (Proceedings Volume 4):

AKKERMAN, KONTER, HILLEN & PILARCZYK: "Design Criteria for Rockfill Closures of Tidal Gaps."

GIESECKE & HORLACHER: "Measuring and Calculating Transient Pressure Fields Resulting from Wave Motion on a Submerged Cylindrical Tank."

GRILLI & SAHLOUL: "Wave Action on Coastal Structures."

HEYER & HOLZ: "A Mathematical Study of the Control of Morphodynamics in a Tidal River."

LAMBERTI, PETRILLO & RANTERI: "A Comparative Analysis of Some Types of Submerged Barriers as Beach Defence Structure."

PILARCZYK: "Stability of Revetments Under Wave and Current Attack."

SCHOLTEN: "The Rhine-Meuse Estuary Hydraulic Scale Model."

SOBEY & JOHNSON: "Wave Diffraction Through A Narrow Gap."

WILLIAMS: "Influence of Form on Tidal Response of Estuarine Lake Inlets in New South Wales."

SELEZOV & ZHELEZNYAK: "Scour of Sea Bottom in Front of Harbour Seawalls."

Seminar (a) Urban drainage hydraulics (continued)

Location: Seminar Room

FLOMEKO '85 Session - 1100-1230 Wednesday 21st August 1985

Velocity Integration

Location: Theatre A

Chairman: Mr. J. Waldron

Co-chairman: Dr. G. Cignolo

Presentation by Authors

Simultaneous translation not provided

Papers:

CHRISTENSEN: "Measurement of Flow, Bed Shear, and Roughness Characteristics in Open Channels by an Air Bubble Device."

TAKEDA, R. & TAKEDA, F.: "Accuracy of the Laser Doppler Velocimeter Systems."

BETTOCCHI & CANTORE: "Experimental Analysis of the Flow in a Conical Diffuser."

1230-1330 Lunch

1330-1730 Technical Inspection: Major pumping station, hydraulic structures on main sewer, and sewage treatment system, Werribee Farm.

1330-1520 FLOMEKO '85 Session

Legal, Metrology, Density, etc.

Location: Theatre A

Chairman: Prof. P. H. Sydenham

Co-chairman: Mr. G. F. Hazzard

Presentation by Authors:

Simultaneous translation not provided

Papers:

HOERLEIN: "The Application of Legal Metrology to Flow-Measuring Equipment in Australia."



DIJSTELBERGEN: "The Measurement of Compressed Natural Gas in Public Refuelling Stations."

PROWSE, LATIF & OWEN: "Calibration of Vibrating Spool Densitometers for LPG Custody Transfer."

ASCHENBRENNER & WATANABE: "Intercomparison of Gas Flow Test Facilities in the USA, Europe and Japan."

**1540-1730 FLOMEKO '85 Session**

Piston Provers

Location: Theatre A

Chairman: Mr. K. Huntsman

Co-chairman: Mr. G. F. Hazzard

Presentation by Authors

Simultaneous translation not provided

Papers (provisional list)

ALASIA & CIGNOLO: "Design Criteria for a 1200 Litre Capacity Piston Prover for Primary Gas Volume and Flowrate Measurements."

BELLINGA, KOOI, HOEKS, van LAAK & ORBONS: "Using a Piston Prover as a Primary Standard in High Pressure Gas Metering."

DIJSTELBERGEN, McKAY & STANNARD: "Commercially Available Gas Meter Provers - An Inter-Comparison of Their Performance."

GROENEVELD: "Gravimetric Calibration of Volumes at the Division of Applied Physics."

Evening: Barbecue and Social Function: Werribee

**THURSDAY 22 AUGUST 1985**

0830-0900 Registration - Logic Classroom, Old Arts Building

**0900-1030 Technical Session 9**

Technical Session 9B - 0900-1030 Thursday 22nd August 1985

Sub-theme B.(b) - Interaction of main channel and flood plain flows

Location: Theatre B

Chairman: Dr. R.J. Keller, Monash University

Session Organizer: Mr. W. T. Wong, Monash University

Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 3):

McKEE, ELSAWY & McKEOGH: "A Study of the Hydraulic Characteristics of Open Channels with Flood-Plains."

RADOJKOVIC & DJORDJEVIC: "Computation of Discharge Distribution in Compound Channels."

ZHELEZNYAKOV: "Problem of Interaction of the Main Channel and the Floodplain Flows."

NALLURI AND JUDY: "Interaction Between Main Channel and Flood Plain Flow."

PASCHE, ROUVE & EVERS: "Flow in Compound Channels with Extreme Flood-Plain Roughness."

Technical Session 9D - 0900-1030 Thursday 22nd August 1985

Sub-theme D.(b) - Measurement of aquifer and stormwater flows

Location: Public Lecture Theatre

Chairman: Dr. A. Muller, Institute of Hydromechanics, Switzerland

Co-chairman: Mr. S. Morgan, Melbourne & Metropolitan Board of Works

Session Organizer: Dr. H.R. Graze, University of Melbourne

**Presentation by Authors**

Simultaneous translation provided

**Papers (Proceedings Volume 5):**

DUDGEON & KESHAVARZ: "Flow & Heat Transfer in a Heat-Pulse Borehole Flowmeter."

HJELMFELT, SPOMER & KRAMER: "Discharge Measurement Problems for Field Size Agricultural Catchments."

ZECH: "Mesure Du Debit Dans Les Egouts Pluviaux."

KLEINSCHROTH, KRUG, SIEGERSTETTER & FRANKE: "Measurements on Unsteady Two-Phase Flow in a Sewage Pipeline."

BOURAS & COMOLET: "Debitmetrie et Volumetrie par Effet Tourbillonnaire."

**FLOMEKO '85 Session - 0830-1030 Thursday 22nd August 1985**

**Nozzles (including Critical Flow)**

Location: Theatre A

Chairman: Dr. D.B. Prowse

Co-chairman: Dr. G. Cignolo

**Presentation by Authors**

Simultaneous translation not provided

**Papers:**

NARJES: "A New Method for the Direct Determination of a Venturi Nozzle's Discharge Coefficient at Transonic Flow."

SNELL: "A Simple Continuous Gas Mixing System Using Sonic Nozzles."

WRIGHT: "The Application of Sonic Nozzles to the Automated Accuracy Testing of Gas Flowmeters."

CAW, BRYANT & PROWSE: "The Comparison of Critical Flow Nozzles Using Networks Analogous to the Wheatstone Bridge."

CAW, BRYANT & PROWSE: "Pressure Divider Measurements to Define Reynold's Number Effects in Critical Flow Nozzles."

1030-1100

**Morning Tea**

**Poster Paper Session (Authors present)**

Location: Corridors, Old Arts Building

1100-1230

**Technical Session 10**

**Technical Session 10B - 1100-1230 Thursday 22nd August 1985**

**Sub-theme B.(b) - Flood flows in channels and flood plains**

Location: Public Lecture Theatre

Chairman: Dr. A. Verwey, Inter. Inst. for Hydraulic & Env. Engg., Delft

Co-Chairman: Dr. E. Pasche, RWTH, Aachen

Session Organizer: Mr. W.T. Wong, Monash University

Presentation by General Reporter, Prof. J.A. CUNGE SOGREAH

Simultaneous translation provided

**Papers (Proceedings Volume 3):**

APELT, LAWRENCE, WELLINGTON & YOUNG: "Mathematical Modelling of Channel - Flood Plain Exchange."

ATKINS & WALSH: "The Peaceful Co-Existence of Lae City and the Bumbu River in Papua New Guinea."

BOEV: "Phenomenons of Floods in Strumica Field and the Function of the Regulation of River Strumica."

DARTOUT, STEIN, LEPELLETIER & VASSILIADIS: "Effets des Barrages Ecreteurs et des Amagements de Vallees sur la Propagation des

Crues du Bassin de la Seine en Amont de Paris mise au Point d'un Modele Mathematique de Simulation."

GABOS & YANG MINQUIN: "A Flood Plain Management Model In China."

KANDA: "Concurrence of Flood Flow and Invasion of Storm Surge in the Tidal River."

RAJAGOPALAN, BELGAL & HARDIKAR: "Consideration of Floodplain Storage for Narmada Design Hydrograph."

TINGSANCHALI: "Computation of Flow in Rivers and Flood Plains Under Different Backwater Effects and Data Constraints: Northeast Thailand."

VONGVISESSOMJAI, TINGSANCHALI & CHAIWAT: "Bangkok Flood Plain Model."

YEN, CAMACHO, KOHANE & WESTRICH: "Significance of Flood Plains in Backwater Computation."

**Technical Session 10C – 1100-1230 Thursday 22nd August 1985**

Sub-theme C.(b) – Numerical and field studies of sediment movement in coastal areas and estuaries

Location: Theatre C

Chairman: Assoc. Prof. R.J. Sobey, University of California at Berkeley

Co-chairman: Mr. B.M. Druery, Dept. of Public Works, N.S.W.

Session Organizer: Mr. D. L. Reid, Monash University

Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 4):

JAIN & KENNEDY: "Sediment-Laden Circular Wall-Jet."

NIELSEN: "Oscillatory Boundary Layers: A Different Problem."

ISAACSON, M.: "Sediment Erosion Around Artificial Islands."

WALTON & DOUGLASS: "Stochastic Sand Transport Synthesis Using ARIMA Modeling."

**FLOMEKO '85 Session – 1100-1230 Thursday 22nd August 1985**

Ultrasonic Flowmeters

Location: Theatre A

Chairman: Mr. P. Sharpin

Co-chairman: Dr. B. B. Sharp

Presentation by Authors

Simultaneous translation not provided

Papers:

SANDERSON & TORLEY: "A Self-Calibrating Clamp-on Transit Time Ultrasonic Flowmeter."

WALUS: "The Use of the Ultrasonic Flowmeter in the Conditions Other Than Normal."

KARRAS, TORNBERG & HARKONEN: "The Ultrasonic Inferential Mass Flowmeter for Solids Carried by the Pulp Suspension."

ERICKSON & BISTRAN: "Application of Ultrasonic Flowmeters to Hydro-electric Plant Flow Measurements."

1230-1400 Lunch

1400-1530 **Technical Session 11**

**Technical Session 11B – 1400-1530 Thursday 22nd August 1985**

Sub-theme B.(b) – Flood flows in channels and flood plains

Location: Theatre B

Chairman: Prof. J.A. Cunge, SOGREAH

Co-chairman: Dr-Ing E. Pasche, RWTH, Aachen

Session Organizer: Dr. H.J. Keller, Monash University

Presentation by General Reporter, Dr. A. VERWEY, International Inst. for Hydraulic and Env. Engg., Delft.

Simultaneous translation not provided

Papers (Proceedings Volume 3):

ALAVIAN & CHU: "Turbulent Exchange Flow in Shallow Compound Channels."

CHEE & RAY: "Conveyance of Channels with Overbank Flow."

CHIN-LIEN YEN: "Routing by Diffusion Method in Channels with Floodplains."

CHRISTENSEN: "Open Channel and Sheet Flow over Flexible Roughness."

KLAASSEN & van URK: "Resistance to Flow of Flood Plains with Grasses and Hedges."

OGINK: "On The Effective Viscosity Coefficient in 2-D Depth-Averaged Flow Models."

REED: "An Example of the Effect of Depth-Sensitive Values of Manning's n on Nonuniform Flow Computations."

ROBERTS, PERNIK & BENKE: "Mixing in River-Floodplain Systems."

WONG: "Reach Sub-Division for Storage Flood Routing in Rivers."

Technical Session 11C - 1400-1530 Thursday 22nd August 1985

Sub-theme C.(b) - Fundamentals of sediment movement in coastal areas and estuaries

Location: Public Lecture Theatre

Chairman: Dr. J. Ploeg, National Research Council, Canada

Co-chairman: Dr. M. de StQ. Isaacson, University of British Columbia

Session Organizer: Mr. D. L. Reid, Monash University

Presentation by General Reporter, Dr H.P. RIEDEL, Riedel and Byrne

Simultaneous translation provided

Papers (Proceedings Volume 4):

BERLAMONT, van GOETHEM, BERLEUR & van BRUWAENE: "A Permanent Mud Pumping Installation as an Alternative for Local Maintenance Dredging."

BRAHME & BAPAYE: "Studies for the Development of a New Approach Channel."

COEFFE, CHALOIN & PECHON: "Application d'une Modelisation Numerique des Courants de Marée et du Transport Solite." ("Applications of Numerical Simulation of Tidal Currents and Sediment Transport.")

JOHNSTON, ELSAWY, HAMILL & McKILLEN: "A Study of Scour and Deposition Near a Berth Structure Caused by Propulsion Action of Manoeuvring Ships."

LENN & ENEVER: "The Measurement of the Size and Concentration of Suspended Fine Sands Using Scattered Ultrasound."

MARKOFKY, LANG & SCHUBERT: "Suspended Sediment Transport in Tidal Waters: Turbidity Maximum, Numerical Simulation, Physical Aspects."

RIEDEL: "Tailings Disposal - Empress Augusta Bay, Bougainville."

van RIJN & NIENHUIS: "In-Situ Determination of Fall Velocity of Suspended Sediment."

Seminar (c) Case studies in hydraulic transients  
Location: Seminar Room  
Seminar Organizer: Mr. E. J. Lesleighter, Snowy Mountains Engineering Corporation

Lead Papers (Proceedings Volume 6):

H. BREKKE: "Analysis of Pressure Surges."

M.H. CHAUDRY: "Aspects of Hydraulic Transients."

Other papers by various authors available at door.

Simultaneous translation not provided.

FLOMEKO '85 Session - 1350-1540 Thursday 22nd August 1985

Cross-Correlation and Constrictions

Location: Theatre A

Chairman: Dr. H.H. Dijkstra

Co-chairman: Mr. S. Morgan

Presentation by Authors

Simultaneous translation not provided

Papers:

BATTYE: "The Industrial Correlation Flowmeter and Its Design Constraints."

KEECH & COULTHARD: "Advances in Cross-Correlation Flow Measurement and Its Application."

KICHEV, THOM & FOORD: "Devices with Measuring Constrictions Elastically Supported."

SHAO CHANGCHUN: "Measurement of Wet Steam Flow."

1530-1600 Afternoon Tea

1600-1730 Technical Session 12

Technical Session 12B - 1600-1730 Thursday 22nd August 1985

Sub-theme B.(f) - Rainfall and runoff models

Location: Theatre B

Chairman: Assoc. Prof. R.G. Mein, Monash University

Session Organizer: Dr. A.H. Wong, Gutteridge Haskins & Davey

Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 3):

HAGER: "A Non-Linear Rainfall-Runoff Model".

WILLIAMS & FIELD: "Real Time Flood-Forecasting Using Non-Linear Conceptual Rainfall-Runoff Models".

HARBOE: "Models for the Security in Areas Protected Against Flood Flows Through Reservoirs."

TSYKIN: "Extrapolation of Rainfall-Runoff Regression Models Outside Their Calibration Range".

BERGMANN & SACKL: "Two Dimensional Frequency Analysis of Flood Water Flow and Its Application in Water Management."

Technical Session 12C - 1600-1730 Thursday 22nd August 1985

Sub-theme C.(a) - Currents in coastal areas and estuaries

Location: Public Lecture Theatre

Chairman: Mr. T.L. Walton, Jr., U.S. Dept. of the Army

Session Organizer: Mr. D. L. Reid, Monash University

Presentation by Authors

Simultaneous translation provided

Papers (Proceedings Volume 4):

BONNETON & GAILLARD: "Numerical Calculation of Wave-Induced Currents."

LEE, LI & CHOI: "Simulation of Tidal Circulation in a Coastal Bay: A Comparative Case Study."

LE HIR & SALOMON: "A Study of Residual Circulation in the Bay of Seine."

van SENDEN: "Structure of Tidal Jets Under Variable Source Conditions."

FUKUOKA, FUKUSHIMA & TSUNODA: "Fresh Water Flow in a River Mouth."

Seminar (c) Case studies in hydraulic transients (continued)

Location: Seminar Room

FLOMEKO '85 Session - 1600-1730 Thursday 22nd August 1985

Pulsating Flow

Location: Theatre A

Chairman: Dr. E. A. Spencer, O.B.E.,

Co-chairman: Dr. H.H. Dijkstra

Presentation by authors

Simultaneous translation not provided

Papers:

MOTTRAM: "Measurement of Noisy and Pulsating Flows in Industrial and Laboratory Environments."

HEBRARD, BISCOS, GAJAN & PLATET: "An Investigation of the Behaviour of Orifice Meters in Pulsating Flow Conditions."

FOSS: "The Calibration of Viscous Flowmeters Subject to Pulsating Flow."

1900 for  
1930

Congress Banquet

**FRIDAY 23 AUGUST 1985**

0830-0900 Registration - Logic Classroom, Old Arts Building

0900-1030 **Technical Session 13**

Technical Session 13B - 0900-1030 Friday 23rd August 1985

Sub-theme B.(d) - Sediment transport in rivers

Location: Theatre B

Chairman: Prof. A. Raudkivi, University of Auckland

Session Organizer: Mr. W.T. Wong, Monash University

Presentation by General Reporter, Prof. K. RANGA RAJU, University of Roorkee

Simultaneous translation not provided

Papers (Proceedings Volume 3):

ARMANINI & DI SILVIO: "Transport of Suspended Sediments Along Channels with a Trench."

CELIK & RODI: "Mathematical Modelling of Suspended Sediment Transport in Open Channels."

GRAF & SUSZKA: "Unsteady Flow and its Effect on Sediment Transport."

HSU & HOLLY: "Numerical Computation of Alluvial River Bend Flow and Equilibrium Geometry."

KARIM & KENNEDY: "Kinematic Analysis of Characteristic Time Scales for Bed Degradation and Aggradation in Alluvial Streams with Nonuniform Sediment."

LU & SHEN: "Evaluation of H. A. Einstein's Hiding Factor for Transport Non-uniform Sediment Sizes."  
 MUKHAMEDOV, JURAEV & ISHANOV: "Investigation of Basic Parameters in Sand Canals."  
 PHILLIPS & SUTHERLAND: "Numerical Modelling of Spatial and Temporal Lag Effects in Bedload Sediment Transport."  
 SINGH & SCARLATOS: "Sediment Transport in Vertically 2-D Man-Made Canals."  
 THOMAS & SUTCLIFFE: "Some Hydraulic Aspects of Sewage Settlement Tanks."  
 WESTRICH & JURASCHEK: "Flow Transport Capacity for Suspended Sediment."

**Seminar (d) Small hydropower generation**

Location: Public Lecture Theatre

Seminar Organizer: Prof. J.L. Woodward, University of Auckland

Lead Papers (Proceedings Volume 6)

D.R. PRESTON: "River Intakes"

J.N. DUDER: "Structures: Construction Material and Techniques and Maintenance"

B.W. LEYLAND: "Mechanical and Electrical Aspects"

Other papers by various authors available at door.

Simultaneous translation provided.

1030-1100 Morning Tea

1100-1230 **Technical Session 14**

Technical Session 14B – 1100-1230 Friday 23rd August 1985

Sub-theme B.(e) – Hydraulic Structures

Location: Theatre B

Chairman: Mr. P. Ackers, Binnie and Partners

Session Organizer: Mr. W.T. Wong, Monash University

Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 3):

GIESECKE & HORLACHER: "Automatically Operating Flexible Weirs in Small Hydro Stations and in Agricultural Irrigation Systems."

OGIHARA & MURAMATSU: "Causes of Oscillation in Rubber Dams and Countermeasures".

DUGGINS & EGGLE: "A Flow Modulator for Hydraulic Applications."

PILARCZYK, KOLKMAN & UWLAND: "Prototype Measurements on Discharge Sluices in the Netherlands."

**Seminar (d) Small hydropower generation (continued)**

Location: Public Lecture Theatre

Poster Paper Session (Authors present)

Location: Corridors, Old Arts Building

1230-1400 Lunch

1400-1530 **Technical Session 15**

Technical Session 15B – 1400-1530 Friday 23rd August 1985

Sub-theme B.(e) – Hydraulic Structures

Location: Public Lecture Theatre

Chairman: Mr. P. Ackers, Binnie and Partners

Session Organizer: Mr. W.T. Wong, Monash University

Presentation by Authors

Simultaneous translation provided

Papers (Proceedings Volume 3):

OGIHARA: "Unstable Condition of Self-excited Oscillation of Flap Gate".

MICHELS: "Rosslynne Spillway: Mitre-Prowed Overfall Weir with Sharply Convergent Walls & Skew-Impacted Trough Apron".

LOPARDO & HENNING: "Experimental Advances on Pressure Fluctuations Beneath Hydraulic Jumps."

BANDLER: "Water Supply to Bandung and Yogyakarta, Indonesia - Environmental Implications and Sanitation Measures."

Technical Session 15C - 1400-1530 Friday 23rd August 1985

Sub-Theme C.(d) - Environmental aspects of estuaries and coastal areas

Location: Theatre B

Chairman: Dr. I.G. Wallis, Consulting Environmental Engineers

Co-chairman: Dr. N. Haritos, University of Melbourne

Session Organizer: Mr. D. L. Reid, Monash University

Presentation by Authors

Simultaneous translation not provided

Papers (Proceedings Volume 4):

BLOSS, WOLLRATH & ZIELKE: "Optimal Control of Discharges Into Unsteady Flows."

MAROTZ: "Head Losses in Intake Pipes of Desalination and Powerplants, Caused by Mussel Incrustation and Methods of Prevention."

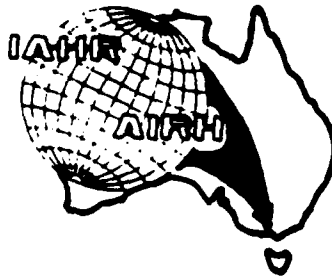
ONISHI & MIYAZAKI: "Theoretical and Experimental Study of Submerged Multiport Diffuser."

UDA & HASHIMOTO: "Field Investigation of Nearshore Circulation by a Remote Sensing Technique."

VAIDYARAMAN & PUTTARAMAIAH: "Discharge of Sediment Laden Water into the Open Sea."

- 1530-1600 Afternoon Tea
- 1600-1800 Plenary Session  
Location: Wilson Hall
- 1600-1620 Address by Prof. J.S. McNown, Royal Institute of Technology, Sweden:  
"Hydraulics on Display."
- 1625-1725 General Assembly of the International Association for Hydraulic Research
- 1730-1800 Closing Ceremony of 21st Congress
- 1800-1900 Farewell Party  
Location: Wilson Hall





International Association for Hydraulic Research  
Twenty First Congress

Opening Ceremony  
in  
The Wilson Hall  
The University of Melbourne  
Monday, 19th August, 1985.

in the presence of their Excellencies  
The Administrator of the Commonwealth of Australia  
Sir James Rowland K.B.E. and Lady Rowland

- Order of Proceedings -

- . Musical interlude
- . Official Party enters Hall
- . National Anthem
- . President of I.A.H.R., Prof. Dr.-Ing. E.J. Plate.
- . Chairman of I.A.H.R. Local Organizing Committee,  
Prof. J.D. Lawson.
- . Chancellor of The University of Melbourne,  
Prof. Emeritus Sir Douglas Wright A.K.
- . Prof. Dr.-Ing. Plate
- . His Excellency, The Administrator of the Commonwealth  
of Australia, Sir James Rowland K.B.E., D.F.C., A.F.C.
- . Prof. Dr.-Ing. Plate
- . I.A.H.R. Keynote Speaker, Prof. Dr.-Ing. G. Garbrecht.
- . Prof. Dr.-Ing. Plate
- . Official Party leaves Hall
- . Refreshments

Music: University Organist,  
Mrs. Constance Calwell.  
Bach and Handel  
(celebrating 300th  
anniversary).



## RURAL WATER COMMISSION

### HYDRAULIC EXPERIMENTAL STATION, WERRIBEE

#### MODELLING WITH WATER

The hydraulic model has been recognised for nearly a century as an essential tool in the design and operation of both large and small hydraulic structures such as dams, spillways, pipelines and channels. Most large water authorities throughout the world have established hydraulic laboratories in which models of water engineering works are constructed and tested.

Model tests permit solution or clarification of many problems which are difficult or insoluble by normal analysis or design methods.

In the great majority of cases, the tests ensure not only safety in operation and economy but also effect substantial financial savings, far outweighing the cost of the experimental work involved.

There are two main types of hydraulic laboratories - Research and Experimental. Pure-research oriented laboratories are concerned with the study of the fundamentals of hydraulics, and are generally attached to universities and colleges of technology and specialised manufacturing organisations. The results of these studies are incorporated in state-of-the-art design techniques.

Hydraulic experimental laboratories are usually incorporated in large government agencies responsible for the operation and management of water supply or navigation undertakings. They are aimed chiefly at aiding the design of hydraulic structures, employing tests or trials for checking or verifying the success of a particular hypothesis for given or different conditions, using a definite procedure.

The Werribee Hydraulic Experimental Station established by the State Rivers and Water Supply Commission, (SRWSC), predecessor of the Rural Water Commission, is of this type, and is an integral part of its Design Division.

#### HISTORY OF STATION

During the design of Yarrawonga Weir on the River Murray in the 1930's, Commission engineers realized that hydraulic model studies would be required. A small model was tested at Melbourne University, and then a larger model in the Commission's Bacchus Marsh District.

In 1947, the enlargement of Eildon and construction of Cairn Curran dams was being planned as part of a program for expansion of water supply in Victoria, the SRWSC decided to establish a hydraulic model testing station as an essential adjunct to the design procedure. Construction commenced in 1949 and the Station was operational in 1950.

Merribee, which is conveniently close to Melbourne, was chosen as the site because land was available adjacent to the existing Commission District Office, with a superseded town water supply concrete settling tank and high level water tower to provide a basis for a recirculating system of water supply.

The Hydraulic Experimental Station has served the State water industry well since then, testing 240 models of all types with benefits to more effective operation and cost savings for water supply systems.

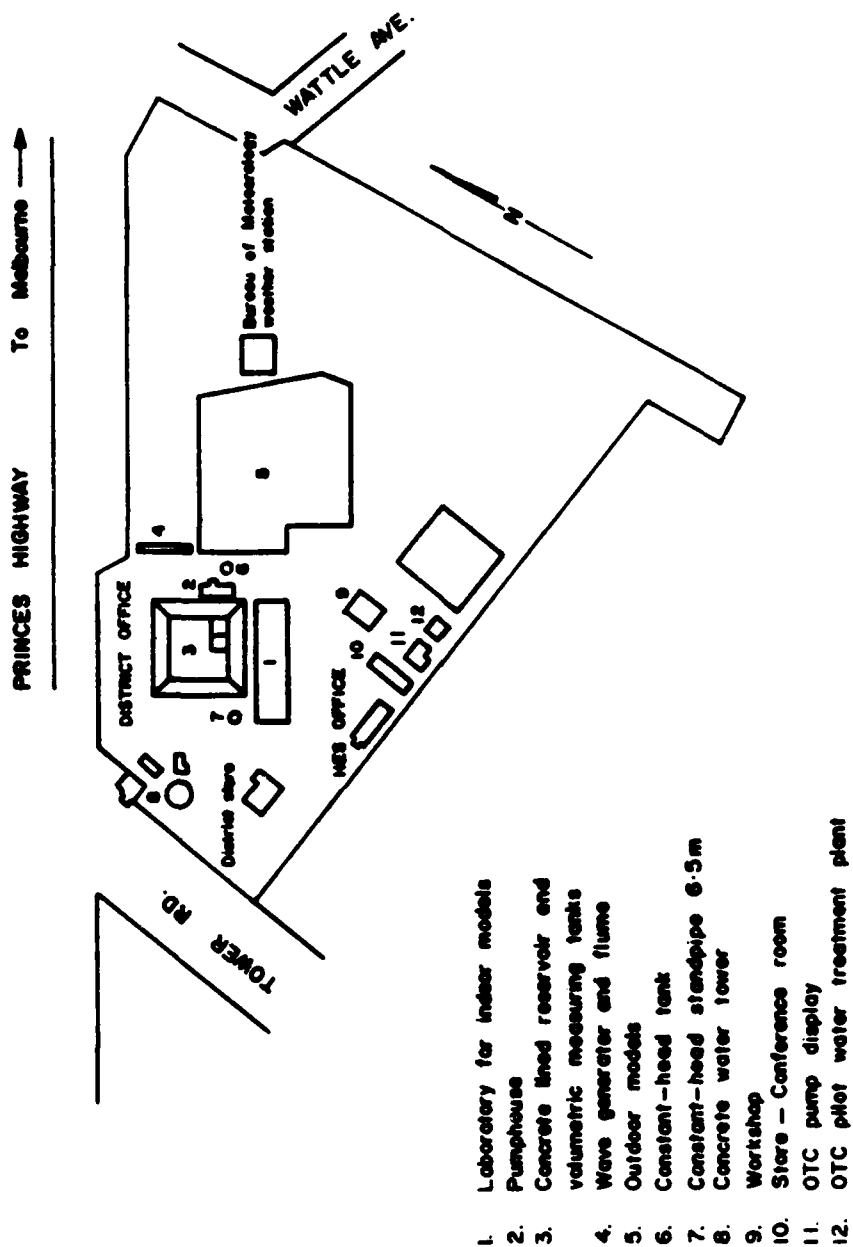
#### STATION FACILITIES

The Station water supply system can provide flow rates up to 300 L/S (26 ML/d) and has National Association of Testing Authorities registration for the calibration of flow measuring devices to an accuracy of  $\pm 0.75\%$  using volumetric measuring tanks. A large laboratory and extensive outdoor area, both with constant head supply tanks, provide excellent facilities for carrying out large scale model tests relevant to the water industry.

The Station has conducted investigations and model testing in the following fields:

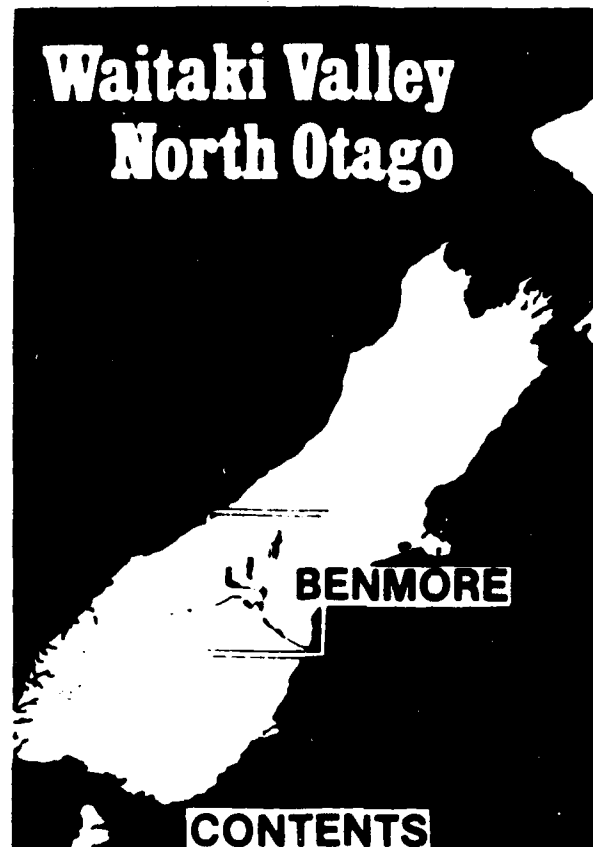
- . improvements to and checking of designs of irrigation and drainage channel structures, including reduction of erosion and improving energy dissipation, calibration of measuring weirs, siphons, offtakes, regulating gates, and pipe flow meters. Results from these tests have contributed to the development of standard structures for irrigation and drainage works.
- . improvements to and checking of design of components such as spillways, outlet works, and energy dissipators for dams.
- . determination of flow characteristics and discharge coefficients of spillway crests of various shapes operating under free-flow or gate-controlled conditions.
- . calibration of propeller and other flow meters for pipe sizes up to 375 mm.
- . river model studies for flood prevention, diversion, drainage and control, and studies in siltation and scour prevention.

The Station is available to carry out studies for other authorities and private organisations. Enquiries should be directed to the Resident Engineer (03 741-2999) or the Commission's Chief Designing Engineer, Major Projects Design Division, 590 Orrong Road, Armadale 3143, Victoria.



Prepared by Designs Draughting  
July 1985

# **BENMORE**



**EARTH DAM CONSTRUCTION STATISTICS**

**RIVER DIVERSION LAKE FILLING**

**INTAKES PENSTOCK SPILLWAY**

**DIMENSIONS FACTS AND FIGURES**

**ELECTRICAL D.C. TRANSMISSION SYSTEM**

**UPPER WAITAKI AND MACKENZIE COUNTRY HYDRO-ELECTRIC DEVELOPMENT**

# BENMORE

## DIMENSIONS

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One half a mile long across the top, one quarter of a mile thick at the base, 360 feet high.

It took five years to place the sixteen million yards (twenty seven million tons) of material in the dam.

The Lake behind the dam extends 22 miles up the Waitaki valley towards Mt. Cook and a further 12 miles up the Ahuriri valley towards Omarama, contains 17 islands, has 32 square miles of surface area and has nearly 100 miles of shoreline. The lake took six weeks to fill instead of the predicted six months and as predicted the dam has moved 2 inches under the weight of the water.

The Spillway has been designed to take twelve times the flow of the river.

The dam, spillway and powerhouse cost sixty million dollars some twelve million dollars LESS than estimated while the direct current powerline to the North Island including the three underwater cables across Cook Strait a further thirty-six million dollars.

The project was officially opened in May 1965 by the Prime Minister Keith Holyoake and guest of honour at the occasion was Prince Bertil of Sweden whose Country supplied much of the direct current electrical equipment.

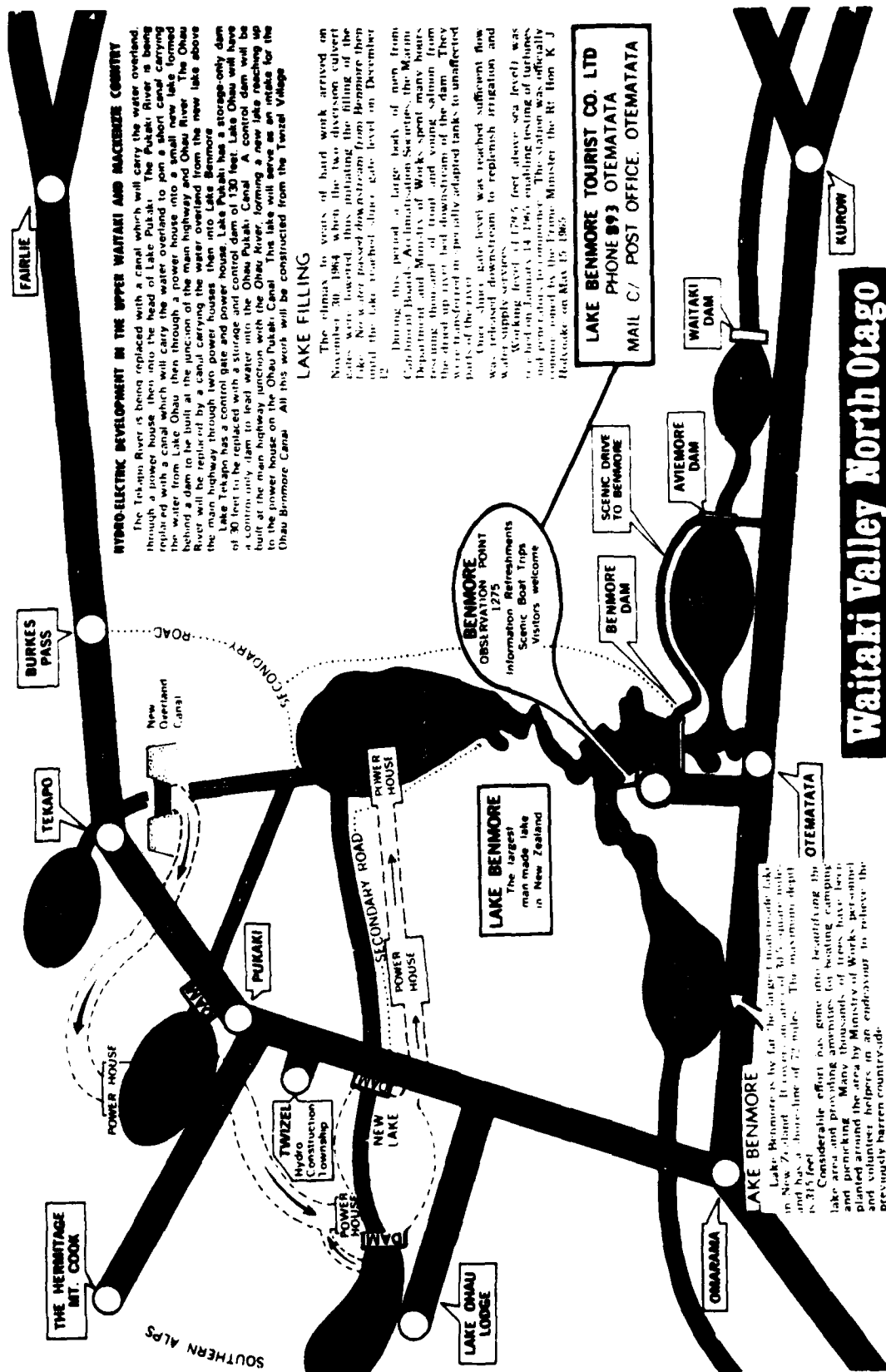
All Benmore power is generated as alternating current but North Island requirements are converted to direct current, transmitted up to and under the sea at Cook Strait and on out to the North Island where it is reconverted back to alternating current to be fed into the National Grid.

This system gives a loss of only nine percent as against a possible forty percent loss with alternating current which in effect is not suitable for transmitting underwater.

The conversion system is Mercury Arc Rectifiers.

# BENMORE





# HYDRO-ELECTRIC DEVELOPMENT IN THE UPPER WAITAKI AND MACEDONIA COUNTRY

The Tekapo River is being replaced with a canal which will carry the water overland, through a power house, then into the head of Lake Pukaki. The Pukaki River is being replaced with a canal which will carry the water overland to join a short canal carrying the water from Lake Ohau then through a power house into a small new lake formed behind a dam to be built at the junction of the main highway and Ohau River. The Ohau River will be replaced by a canal carrying the water overland from the new lake above the main highway through two power houses then into Lake Benmore. Lake Benmore has a storage-only dam of 30 feet to be replaced with a storage and control dam of 130 feet. Lake Pukaki has a control dam to be replaced with a storage and control dam of 130 feet. A new lake, Lake Ohau, will be formed behind a dam to be built at the junction of the main highway and Ohau River, forming a new lake reaching up to the lower reaches of the Ohau Pukaki Canal. This lake will serve as an intake for the Ohau Benmore Canal. All this work will be constructed from the Tenzel Village

## LAKE FILLING

The climax to years of hard work arrived on November 30, 1964, when the two diversion culvert gates were lowered, thus initiating the filling of the lake. No water passed downstream from Benmore then until the lake reached three gate level in December 12.

During this period a large body of men from Government Board, Acclimatization Society, the Marine Department and Ministry of Works spent salaried time in the filling of the lake. The water was transferred in specially adapted tanks to unaffected parts of the river.

Three shut gate level was reached sufficient flow was released downstream to replenish irrigation and water supply services.

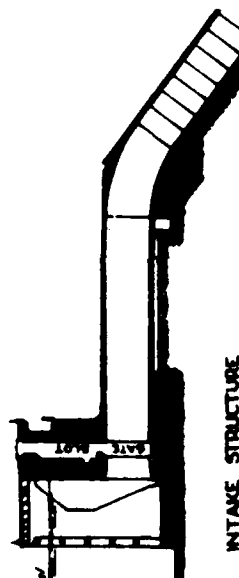
Working level of 129.5 feet above sea level was reached on January 14, 1965, enabling testing of turbines and generation to commence. The station was officially opened by the Minister of Works, Mr. R. H. M. R. J. Holland, on May 15, 1965.

**BENMORE OBSERVATION POINT**  
1275  
Information Refreshments  
Scenic Boat Trips  
Visitors welcome

**LAKE BENMORE**  
The largest man-made lake in New Zealand

**LAKE BENMORE**  
Lake Benmore is by far the largest man-made lake in New Zealand. It covers an area of 34.5 square miles and has a shore-line of 72 miles. The maximum depth is 315 feet. Considerable effort has gone into beautifying the lake area and providing amenities for boating, camping and picnicking. Millions of trees have been planted around the area by Ministry of Works personnel and voluntary helpers in an endeavour to relieve the previously barren countryside.

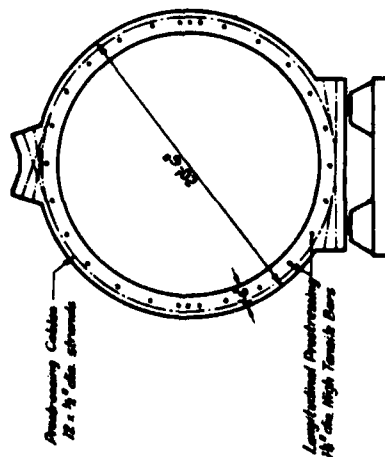
Bennore's main features are the huge earth dam, the intake block, penstocks and powerhouse situated on the Otago side, and the spillway structure at the Canterbury side of the dam.



### INTAKE BLOCK AND PENSTOCKS

Lake water is fed to the powerhouse through the intake block and down six concrete penstocks. The Bennore penstocks are amongst the largest of their kind in the world.

Constructed of pre-stressed concrete, each is made up of 53 separate sections weighing 58 tons. They have an internal diameter of 17 feet 6 inches and are 18 inches thick. The 489 ft. long penstocks are positioned on a 35 degree slope.



Cross-section of a pre-stressed concrete penstock, showing the longitudinal and circumferential pre-stressing tendons. The six penstocks, each 4200 ft. long, are cast in 8 ft. sections. Each section weighs 58 tons. The internal diameter is 17 ft. 6 in. Some 318 sections are needed to complete the six penstocks.

The Waitaki River is fed by lakes Tekapo, Pukaki and Ohau, and flows to the East Coast of New Zealand's South Island forming the boundary between the provinces of Canterbury and Otago.

The headwater lakes, in turn, are glacial and snow-melt fed from the Southern Alps: a high mountain chain running almost the full length of the South Island.

The Waitaki's high hydro-electric development potential has long been recognised and power stations now operating under construction, or proposed, may eventually harness the river for power generation along almost its entire length.

Lakes Tekapo, Pukaki and Ohau assist in balancing the river flow throughout the year but their natural discharge tends to be low in the winter and high in the summer.

Control dams constructed at the outlets of Tekapo and Pukaki have increased their storage capacities so the higher inflow during the thaw can be conserved for release in winter when the consumer demand for power is at a maximum.

### D.C. TRANSMISSION SYSTEM

Two 220,000 volt lines lead off from the outdoor A.C. station to link Bennore with the South Island network. One runs 160 miles north to Invercargill, the other 35 miles south to Dunedin. The line south will later become two lines to Avenmore power station.

At the foot of the penstock slope are the powerhouse buildings. Downstream of them, on the right bank of the river, is the converter station which changes alternating current at 110,000 volts into direct current at 500,000 volts for transmission to the North Island via the 378-mile inter-island link. On the left bank is the outdoor alternating current station through which power is supplied to the South Island transmission network. This dual character - the capacity to supply the north through a direct current system and the south through an alternating current one - makes Bennore unique among New Zealand power stations. By increasing the allocated generation to either island as desired, hydraulic conditions throughout New Zealand can be balanced.

The basic process of conversion from alternating to direct current is performed by the 24 mercury arc valves. Electrical current passes from the anode, the top of the valve, down via four cylindrical tubes and the mercury vapour to the cathode, the base of the valve. The valves alternatively stop and start the flow of the current passing through them at a very rapid rate and thus transform the normal pulsating current into steady flowing direct current.

The valves and control equipment are located in a fully air conditioned valve-house which is completely shielded by a steel mesh inside the walls to reduce radio interference. There is also much outdoor equipment of a special nature, the most impressive items being two smoothing reactors which are used to reduce the ripple in the D.C. voltage. These weigh 80 tons each and for technical reasons stand on four 8-foot-high porcelain insulators.

About 3 miles from the power station, but closely associated with the converter equipment, is the Bennore land electrode where current passing through the earth from the North Island is collected for return to the converter equipment. The design of this electrode was a major undertaking because no information was available on any comparable electrode. It extends over an area of 600 x 700 yards and consists of 2,300 yards of heavy steel rod and 350 tons of coke buried in six radial trenches.

Total capacity of the converter station and D.C. transmission link is 600 megawatts. This is 60 megawatts more than that of Bennore generating station, but power generated elsewhere in the South Island can be fed into the link via the Bennore converter station to make up the 600 megawatts if required.

At present the installation is the most powerful of its kind in operation with the exception of one in the U.S.A. The D.C. link is the longest in the world by a substantial margin.

For the average visitor, however, Bennore's chief attraction lies in its vast dam and in the magnificent lake which has been created in formerly barren hill-country. It is already a tourist attraction and its beauty will increase as the thousands of trees now being planted about it grow to maturity.

## POWERHOUSE

Two 220,000 volt lines lead off from the outdoor A.C. station to link Benmore with the South Island network. One runs 160 miles north to Invercargill substation, the other 35 miles south to Livingstone. The line south will later become two lines to Aviemore power station.

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## ELECTRICAL

**Energy (Kwh)**  
(kilowatt-hour) is the unit which electric power does in a given period, and is power multiplied by time. A kilowatt-hour is known commercially as a "unit". Your power bill is charged according to the number of units used. A one-bar electric heater, for instance, will use one kilowatt in one hour, i.e., it will use one "unit".

## SPILLWAY AND SLUICE STRUCTURE

Periodically, into the lake behind the dam, there will be a flow of water too great for power generating purposes. In this eventuality, the spillway structure will act as a safety valve, passing excess water down a 1,440 feet long channel. The spillway sluices enable the lake to be lowered if required for maintenance purposes.

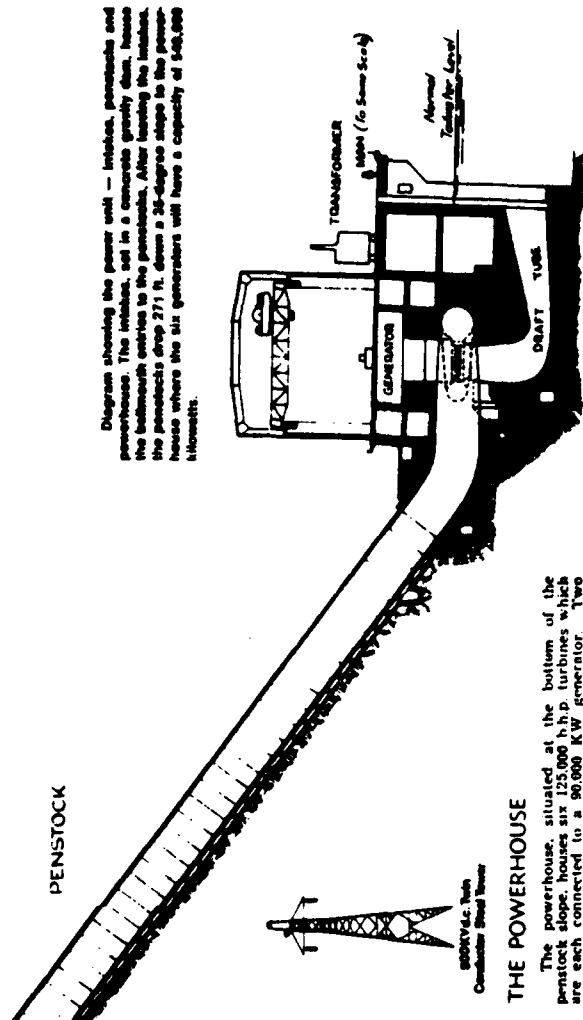


Diagram showing the power unit — turbines, penstocks and powerhouses. The turbines, set in a concrete gravity dam, house the bulb-turbine entries to the penstocks. After leaving the turbines, the penstocks drop 271 ft. down a 35-degree slope to the powerhouse where the six generators will have a capacity of 600,000 kilowatts.

POWERHOUSE

The powerhouse, situated at the bottom of the penstock slope, houses six 125,000 h.p. turbines which are each connected to a 90,000 K.W. generator. Two penstocks lead from the turbines to the powerhouse for various local purposes. The main powerhouse structure is 480 feet long, 140 feet high from excavation to roof top and is constructed of reinforced concrete. Adjacent to the main building are a workshop, office block and control block.

Before major construction work can commence in earnest on a hydro-electric scheme the course of the river must be controlled so that work can be carried out in dry conditions. To effect this at Benmore a twin-limbed culvert was constructed, each tunnel being 41 feet high, 25 feet wide and 1,440 feet long.

The culvert was designed to carry six times the normal river flow which was the maximum flood likely to occur during the critical construction period.

The river was successfully diverted to flow through the culvert in August, 1960.

## WAITAKI HYDRO-HISTORY

Also authorities claim that the earliest inhabitants of the Waitaki Valley were a native race, the Nga-pahi. Evidence of their dwelling in this area has been discovered only recently, that is to say within the last few years. The earliest remains, chiefly of primitive designs, found in the wall of the Waitaki River, which are to be found at various sites in the valley.

From time to time other relics in the form of oven pits, sometimes, (remains of the food itself, have been unearthed to give weight to the theory that in some bygone age hunters did rely on this area to provide them with their daily food.

Legend tends to conflict when it comes to determining the period of these people but there seems to be a general agreement that the earliest settled around the Lake Hawera district. These people, however, came to that lake and may have been there as early as the fourth century. About 1350 a substantial party of the Waitaha tribe arrived in the area and this name seems to have been applied to all native dwellers who arrived up to the mid-fourteenth century.

The year 1550 saw the invasion of the South Island by the Ngati-mahoe and some 100 years later, the Ngai-tahu. These two peoples, in spite of long periods of peaceful exploration and some inter-marriage, were warring enemies and both used sheltering places in the Waitaki Valley during the course of their inter-tribal campaigns.

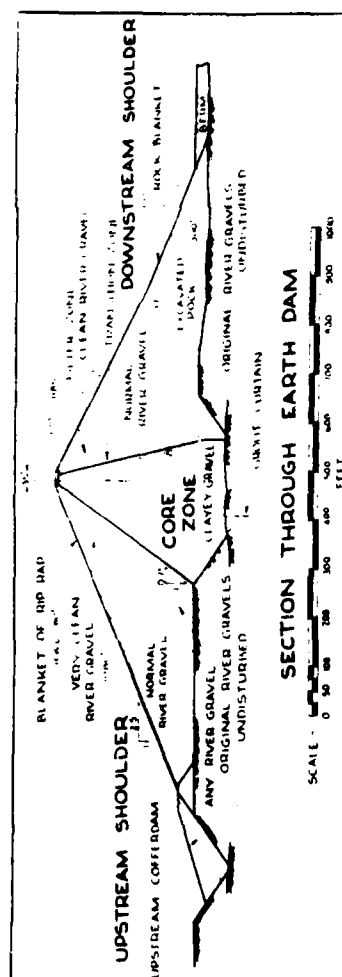
As the Waitaki River serves commerce today with its various power stations, so it did long before the coming of the white man, though in a more indirect way. For it was along the banks of this river that the Maoris often travelled on the way to the West Coast for the coveted panamau, or greenstone.

No history of the Waitaki Valley, no matter how brief, can be told without some mention of the Hon. Walter B. D. Maniell, for it was he who was responsible for the early exploration and description of the area as the first European to penetrate into the Upper Waitaki country.

Maniell undertook this expedition in 1848 as part of his office as commissioner appointed to settle native affairs in the South Island. Following a crude map drawn by his native guide Te Ware Korari, Maniell explored the countryside as far as present-day Upper Waitaki, and subsequently further. He reached Omarama in December 1852. The year in which it is said that expeditions under Maori leaders were still to be found in that time a few native villages were still to be found in the valley, but the majority of the Maoris had shifted to Maccra.

From 1853 isolated homesteads began to appear in the valley and heralded the era of the runholder. Oramatata (Rev. J. C. Andrews), Te Akatarawa (Edmund Gibson) and Haldon (Frederick and Thomas T. Haldon) and H. J. Le Cren all came into prominence. The year 1857 and still dominate the local scene under the present holding families—the Camerons, Whalans and Innes.

But there is another story.



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## SPILLWAY, INTAKES, PENSTOCKS

The behaviour of the dam under working conditions is checked by reading gauges in three instrument-houses, two located on the downstream face and one in the right concrete abutment. These gauges are attached by long plastic tubes to piezometers (instruments for measuring water pressure between the core particles) and hydrostatic settlement gauges, placed inside the dam during construction.

The dam holds back New Zealand's largest man-made lake which covers 40 square miles and contains one-and-a-half times as much water as Wabington harbor. Under operating conditions water level can be controlled over a range of up to 20 feet, though in practice fluctuations are much smaller. Normal retention level is 10 to 12 feet below the dam crest, i.e., 1,175 to 1,180 feet above sea level. Under very unusual circumstances, for example, if it became necessary to dewater the intake structure in order to repair it the lake could be drawn down to 1,100 feet above sea level, by means of the sluice gates located to the left of the dam looking downstream.

The 124-foot-high concrete spillway structure, besides the two sluices in its base, has four radial steel gates at retention level. Maximum rate of discharge through the gates is 120,000 cubic feet per second, which is the worst flood likely to occur in a 1,000 year period, or 10 times the normal rate of outflow. The sluices can discharge a further 40,000 cusecs. Water passed through the spillway runs down a sloping channel to a deflector which fans it into a wide arc and thus dissipates its energy before it enters the river.

At the opposite end of the dam are the intake block and 271-foot-high penstock slope. The former consists of massive concrete blocks, containing six bellmouth entries which lead into the six main penstocks. The entries are regulated by 164-ton gates and are protected from floating debris by screens placed between the piers of a bridge immediately upstream of the intake structure. Because of their bulk and the need to maintain a very high quality of concrete the main sections of the penstocks were not built in situ. Three hundred and eighty prestressed concrete units, each 8 feet long, 17 1/2 feet inside diameter and weighing about 56 tons were built in a casting yard about a mile away, transported individually to the top of the slope and winched down into position, each unit being placed 14 inches above the preceding one and joined to it by coupling the longitudinal prestressed bars and pumping fluid mortar into the vacant space. Short sections near the intake and leading into the powerhouse were built in situ of reinforced concrete with a steel liner.

The penstock structure measures 670 feet from intake mouth to spiral turbine casings and conveys water from the lake to the turbines at a rated net head of 302 feet.

## Power Terms

Voltage (V) is the pressure of electricity and is measured in volts.

Current (A) is the flow of electricity and is measured in amperes (amps). Current (in amps) multiplied by voltage (in volts) approximately equals power (in watts). In other words, 1 amp by 1 volt equals 1 watt.

## CONSTRUCTION RIVER DIVERSION

Benmore is the third and largest of a series of stations to be built in the Waitaki River Basin. It stands just below the confluence of the Waitaki and Aheru rivers, a site chosen for investigation in 1946, as being particularly suitable for a large earth dam. Prior to this, several years had been spent investigating a site 3 miles upstream where the Waitaki passes through a narrow gorge known as Black Jack's Point, which seemed suitable for a concrete dam, but with the development of large earth-moving equipment the relative costs of earth dams diminished and the more open site downstream became the more attractive alternative. Government approved it in 1957 and in 1958 work began on the river diversion.

The 1,400-foot long diversion culvert, now under the dam, was built in a large trench excavated on the left bank of the river. It consisted of two arch concrete barricks, 41 feet high by 25 feet wide and capable together of taking almost six times the normal river flow. The river was diverted into them in August 1960. Four years later, when the time came for lake filling, they were closed by lowering two 153-ton steel gates from concrete towers built over the culvert near its upstream end, and by partial backfilling with gravel. Later rock-fill and concrete plugs were added to make a permanent water seal.

The dam spans the valley between two natural promontories, one accommodating the spillways, the other the intake block and penstocks. Its construction was the largest job of its kind ever undertaken in New Zealand and involved carting and compacting 20 million tons of material. The core consists of a barrier of impervious clayey gravel resting on a grouted rock surface. Supporting the core are two massive shoulders of river gravel, with an outer layer of rock rip-rap as protection against wave erosion and the elements. The upstream shoulder has a more porous grade of gravel in the top 120 feet to accelerate drainage when the lake is being lowered, while at the bottom it incorporates a roller dam used during river diversion.

The Benmore Dam is one of the largest earth dams in the world and holds back the largest man-made lake in New Zealand. Benmore is the largest D.C. transmission station in the world.

### STATISTICS

Maximum structural height, 360 ft  
Width at base, 1,600 ft  
Width at crest, 35 ft  
Length at crest, 2,700 ft  
Overall length, 1/2 mile  
Volume, 16 million cu yds  
Four spillway gates, each 67 tons  
Two sluice gates, each 54 tons  
Average water flow in river, 12,000 cusecs

### FACTS AND FIGURES

Capacity, 600,000 KW  
Max. Operating Voltage, 541,000 Volts  
Efficiency Overall Approx. 90 %  
Number of Valves, 26  
Voltage per Valve, 125,000 Volts  
Current per Valve, 1,200 Amps  
Length of Line, 355 miles  
Length of Cable, 25 miles  
Number of Towers, 1,646

## BACKGROUND

Proposals for developing water power schemes on the Waitaki River were included in comprehensive reports on all sources of water power then known in the Dominion which were submitted to Government by an American consulting engineer and the Superintendent Engineer for the then Public Works Department in 1904.

Built recognised the high potential of the river basin and reported it in glowing terms, but they were practical men and had to take into account the immediate needs of the community of those days as well as the nation's limited capacity to finance and construct large works. They had to reject schemes which by present day standards would be ideal.

No one then could put together the numerous jigsaw puzzle of a hydro electric scheme.

Detailed design and the solutions to problems brought to light by investigations are worked out by teams of engineers, architects, draughtsmen and technicians skilled in hydraulic concrete technology, structural analysis, soil mechanics, building construction and the use of mechanical equipment. This work results in the drawings, specifications and other technical instructions.

Power (W) is the rate at which electrical energy is produced or consumed. Power is measured in watts, or more conveniently in kilowatts (thousand of watts), megawatts (millions of watts or thousand of kilowatts) or even in gigawatts (millions of kilowatts).

## REGENERATION

Considerable effort is lent by the Ministry of Works towards ensuring that the dam and lake areas of new hydro-electric schemes add to the attraction of the countryside. Dams are designed to blend in as well as possible with the adjacent area, and boat harbours, camping grounds and picnic areas are established at suitable locations around the lake sides.

Trees offer one of the best means of improving the scenery and many thousands are planted each season with this in mind. In 1965-66 season alone, more than 80,000 trees were planted about the Benmore-Avenmore area. A good survival rate has been achieved so future generations will benefit greatly from the effort applied in this direction now.

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## Machinery and Access:

Benmore's earthmoving and mechanical equipment is impressive even by world standards. Ministry of Works and contracting plant used on the earth dam is set out in the following table:—

### BULLDOZERS:

Machine	Number on Project
Caterpillar D8s	31
Caterpillar D9s	6
Caterpillar D7s	1
Caterpillar D4s	2
International TD25s	2
Euclid TC12s	3
Euclid C6s	2

### RUBBER-TYRED SCRAPERS.

International 495s	15
Caterpillar 631s	4
Caterpillar DW21s	10
Euclid TS24s	3
Euclid S18	1

### EXCAVATORS:

Marion 111M 4yd.	4
Osgood 2½ yd.	2
Marion 40A 2½ yd.	1
NCK ¾ yd.	2
Caterpillar 944 Front-End Loader.	2
2¼ yd.	2
Allis Chalmers 6G F.E.L. 1½ yd.	1

### DUMP WAGONS:

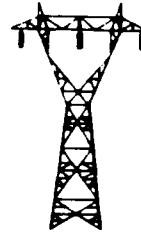
Haulpak 27	10
Euclid 49FD and 82FD	11
Euclid B3FD	9
Euclid BITD	8

### MISCELLANEOUS:

Airtrac Drills	8
50-ton rubber-tyred rollers	4
Vibrating rollers	9
Graders	6



110 KV a.c. Double Circuit Steel Tower



220 KV a.c. Steel Tower



220 KV a.c. Double Circuit Twin Conductor Steel Tower

## FISH PROTECTION

For a week after the river was sealed off at Benmore to effect the filling of the lake, up to 100 men were occupied rescuing thousands of fry and small fish from ponds in the river bed downstream.

At Aviemore, an artificial spawning race for trout is to be built below the dam. Large enough to accommodate 3,000 adult trout, the race will enable fish to be reared in natural conditions.

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